PHYTOPATHOLOGY

VOLUME 26 NUMBER 5

MAY, 1936

HERMAN JOHN NINMAN
1876–1934

S. B. FRACKER

With the death of Herman J. Ninman on October 24, 1934, phytopathology lost one of those consistent and unassuming workers to which every field of science owes so much. Developing from a background in which the forests of northern Wisconsin were an important and ever-present part, he became associated with the white pine blister-rust work almost immediately after its discovery in the Middle West, and for the 17 years from that time until his death he was engaged in various research, survey, quarantine enforcement, and field-control activities connected with the suppression of that disease.

Mr. Ninman was born in Belle Plaine, Wisconsin, on May 4, 1876. His successful efforts to secure even a common school education represented a bitter struggle during which it was necessary for him to be employed continuously in various laborious jobs, which occupied all his time outside the schoolroom. Surmounting these difficulties, he completed a course in the Shawano High School, in 1900; and from then until 1905, he taught in the rural and grade schools of Shawano County. He attended Oshkosh Normal School, Oshkosh, Wis., in 1905, and the State Normal School at Stevens Point from 1906 to 1909. During 1909–10 he was principal of the Melrose (Wis.) High School. This was followed by three years' attendance at the University of Wisconsin, where he was graduated, receiving the degree of Bachelor of Science in Agriculture in 1913. He acted as principal of the Tripoli High School for a year and a half (1914–15) and later returned to the University for postgraduate work, receiving a Master's degree in plant pathology in 1917.

From February 1 to April 30, 1917, Mr. Ninman was employed by the Federal Bureau of Plant Industry as assistant in Tobacco Disease Investigations. That same season the first large-scale suppressive activities directed against the white pine blister rust, which had been found in the northwestern part of the State the year before, were begun, and Mr. Ninman became a member of the scouting crew. A brief period as nursery inspector in the office of the State Entomologist of Wisconsin followed. On December 16, 1918, he received a permanent appointment with the Bureau of

Plant Industry of the U. S. Department of Agriculture as field assistant in white pine blister-rust control and quarantine enforcement. His training in plant pathology, his own personal experience in blisher-rust control, and his knowledge of the people and of Wisconsin conditions made him particularly successful in that work, and he had the responsibilities of State leader of the project for about 12 years. In 1928 he visited Germany and made a series of careful observations on silvicultural methods, the regional adaptation of tree species, and land utilization. During the last 4 years of his service he was in charge of the research phases of the blister-rust-control project in Wisconsin, except for two brief periods of assignment to quarantine enforcement and to the inspection of white-pine-growing nurseries. Death occurred at Waukegan, Ill., only a few hours after he had become ill while engaged in that locality in field work for the Federal Bureau of Entomology and Plant Quarantine.

Five published papers bear Mr. Ninman's name as author; they are

White Pine Blister Rust. Wisconsin Hort. 13: 106–108. 1923.

The Farm Woodlot in Wisconsin. Wisconsin Farmer 56: 353, 361–363. 1927.

Effect of pasturage on white pine reproduction and on timber quality. Jour. Forestry 25: 549–554. 1927.

Notes on European forestry. Jour. Forestry 27: 878–881. 1929.

White pine blister rust control. Wisconsin State Dept. Agr. Bien. Rept. (1927–1928) Bull. 98: 114–117. 1929.

Mr. Ninman's contributions to the development of white pine blister-rust control are much more extensive than this brief bibliography indicates. In the *Blister Rust News*, a mimeographed monthly letter widely distributed among those interested in the protection of white pine, we find that Mr. Ninman contributed 5 articles in 1924, 3 in 1925, 2 in 1926, 4 in 1928, 3 in 1929, 1 in 1931, 1 in 1932, and 3 in 1933. The subject matter ranges from general statements on the Wisconsin blister-rust situation for the season concerned to reports on the rooting of Ribes after eradication, the susceptibility of *Ribes missouriense*, the range of the Hudson Bay currant, and the red squirrel as an assistant in blister-rust control, and also includes a number of comments on the possible spread of blister rust by tourists transporting white pines.

In addition, Mr. Ninman is author of some 25 office reports, some of which relate to pine surveys in Wisconsin and Nebraska, and others to the results of the establishment of experimental plots in which various methods of eradication were tested. Among the subjects covered are: Types of tools and their efficiency; the methods of marking the strip lines in crew eradication; the comparative effectiveness of hand pulling and pick pulling; the disposal of uprooted bushes; the average annual growth of Ribes

branches; the effect of Ribes removal on game; the survival and growth of Ribes seedlings, and a general report on Ribes ecology.

Mr. Ninman labored throughout his life under physical handicaps and in his early years secured his education by overcoming severe obstacles and without having those surrounding local incentives for endeavor which constitute a considerable part of the inspiration for most of those who are interested in science. His unassuming altruism was reflected not only in his scientific work but also in his personal character, with the result that only a few of his closest friends knew of the extent to which he was continuously helpful in providing moral and financial encouragement to relatives seeking an education and to others with whom he came in contact who were in need.

THE PINEAPPLE ROOT SYSTEM AS AFFECTED BY THE ROOT-KNOT NEMATODE[1]

G. H. GODFREY[2]

(Accepted for publication June 4, 1935)

This paper on the pineapple *Ananas comosus* (L.) Merr. as affected by the common root-knot nematode *Heterodera marioni* (Cornu) Goodey gives a detailed description of the symptoms produced on pineapple root systems, and accumulated information from experiments and observations on the changes produced in the root system by the varying population of nematodes in the soil. Figure 1, A represents a typical condition of severe root knot in the pineapple. The circumstances under which such a condition comes about have an important bearing on the understanding of the relationship of original soil-nematode populations to plant growth and yield, and, consequently, on the significance of the degree of efficiency of any particular control measure.

The question arises as to just how many nematodes are necessary to bring about immediate retardation of growth in an individual root. How near to the root must this population be to produce this immediate effect? How large a total population in the soil around the plant is necessary to bring about an early detectable effect on the plant growth? What is the course of events whereby a plant obtains an early vigorous start and, later, in its growth, shows heavy nematode infestation? These questions are answered, in part at least, in the present paper, by the results of specific investigations and extensive observations.

LITERATURE REVIEW

Complete understanding of the subject matter demands some knowledge of pineapple culture. Three papers are of outstanding value in this connection—those by Henrickson (25), Vosbury and Winston (37), and more recently the very comprehensive book on the pineapple by Johnson (28). A number of general treatises on tropical and subtropical agriculture include sections on pineapple, notably Barrett (1), Bester (2), Bruttini (4), Fenzi (12), Noter (31), Semler (32, *Bd. 2*), and Wohltmann (38). Study

[1] Published with the approval of the Director as Technical Paper No. 62 of the Experiment Station of the Pineapple Producers Cooperative Association Ltd., University of Hawaii.

[2] Grateful acknowledgement is made to Dr. R. N. Chapman, Director of this Station, for helpful criticism and advice, and to the members of the Nematology staff, particularly Miss Juliette Oliveira and Mr. Charles Sawicki, for routine phases of the research work. The writer takes full responsibility for his interpretation of the experimental results.

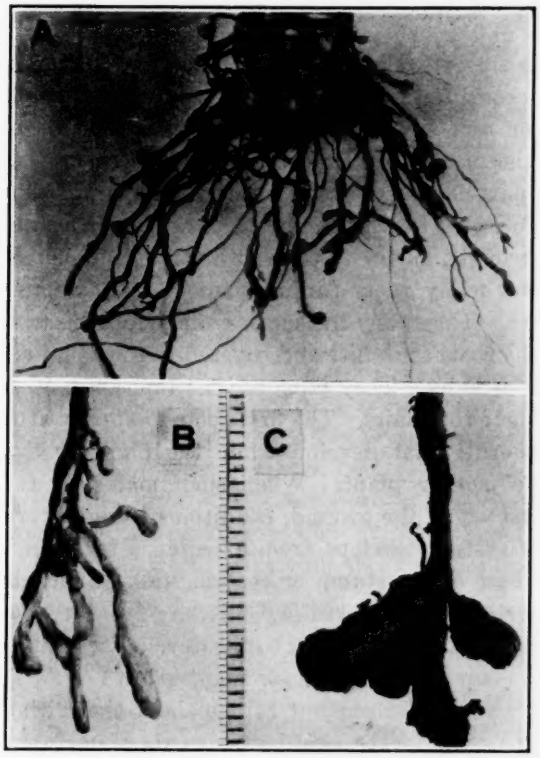


FIG. 1. A. Extreme case of root knot in pineapple, typical of what is to be seen in fields badly infested with the nematode, *Heterodera marioni*. Most of the galls shown are terminal, with a few roots showing nonterminal swellings. About × ½. B. and C. Typical cases of brooming of roots of pineapple brought about by heavy infestations and reinfestations by the root-knot nematode. B. A young branch root heavily infested. C. Original root end and 3 branches, all heavily infested and beginning to break down from invasion by secondary organisms. Magnification indicated by millimeter scales.

of any of these articles gives a general idea of special methods of propagation, culture, etc. Bowers (3) has written at length on the root system of the pineapple plant and has included general statements on the effects of nematodes and other root parasites. Godfrey and Oliveira (20) illustrate with photographs the relationship of the root-knot nematode in different stages of development to individual roots. Collins and Hagan (10, 22, 24) give accounts of studies of effects of nematode inoculations on several pineapple varieties, with detailed statistical analyses of varietal differences in amount of visible infection and in reaction to infection. Godfrey (17) gives a statistical analysis of the effects of different initial nematode populations, as brought about by chemical treatments, on pineapple plant growth and yield.

THE NORMAL ROOT SYSTEM OF THE PINEAPPLE PLANT

As has been suggested by L. R. Jones, of the University of Wisconsin (intermittently consultant at this Station), the various types of abnormality of the pineapple root system cannot be fully understood until the normal root system is thoroughly understood. Much still remains to be determined in this regard, particularly, concerning its physiological aspects. A general description is included here to facilitate the reader's comprehension of the abnormalities brought about by the root-knot nematode. The normal root system comprises many roots (approximately 100) ranging from 1 to $2\frac{1}{2}$ mm. in diameter. They vary in length from 1 to 2 in. to as much as 3 ft. When young, the roots are white and covered in the usual region back of the root tip with root hairs. They later become tan, and still later brown and woody, losing their root hairs. The first roots to appear after planting arise from root primordia that develop while the planting materials are still attached to the mother plant. When such materials (slips, crowns, or suckers) are first set in the ground, conditions being favorable for growth, this initial root system develops from a region $\frac{1}{2}$ to $1\frac{1}{2}$ in. long on the periphery of the base of the stump or central stalk of the planting material. The initial vigor of plant growth depends largely on that of this first root system. Any condition detrimental to the development of a good early root system results in correspondingly poor plant growth.

Subsequent growth of the plant brings about the initiation of new root primordia in the axils of the new leaves as they attain full development. These grow into the soil and become the root system of the plant. Sometimes new roots appear gradually, one or more at a time; again, a large number may develop and grow into the soil at one time, followed by a period without new root development. The conditions governing new root development are not fully understood. Large branches develop occasionally on main roots. Branch rootlets arise abundantly throughout the length of the main roots, most of them only about $\frac{1}{2}$ mm. wide, from 5 to 20 cm. long, very irregular, and much branched. The history of the development of the pineapple root system is of prime importance to the study of the root-knot problem.

The pineapple belongs to the family of "air plants," the Bromeliaceae. In its growth it frequently manifests its likeness to the other members of the family. It is remarkably tenacious under unfavorable conditions, particularly shortage of soil moisture. Plants with very meagre root systems frequently not only continue to live but to grow and bear. The new axillary roots grow round and round the plant stump, beneath the leaf bases, and undoubtedly function as do the aerial roots of other Bromeliaceae, *e.g.*, Tillandsia, by absorbing moisture from light rains and dews. Such roots fre-

quently serve to carry a plant with a very poor soil-root system through to fruiting, particularly if fertilizers are applied by "base-leaf feeding," a method commonly used in pineapple culture.

The pineapple plant must be recognized, then, as having a root system very different from those of the usual agricultural crops. In attempting studies on factors that bring about abnormality in the root development, this fact must be taken into consideration. The very obvious symptoms of abnormal growth induced by the root-knot nematode have led to special attention to its effects on the plants.

The size of the gall is limited definitely by the normal limitation in root diameter. Once a gall is fully developed as the result of a primary invasion by nematode larvae from the soil, it no longer increases in diameter. This type of reaction to nematodes is inherent in the monocotyledonous plants. It occurs with sugar cane *Saccharum officinarum* L.: (9, fig. 28), with banana *Musa sapientum* L., with sorghum *Holcus sorghum* L., with *Syntherisma chinensis* Hitch., and with other grasses sometimes seen heavily infested with nematodes. With dicotyledonous plants, continued development in size of a gall may occur following the development of successive

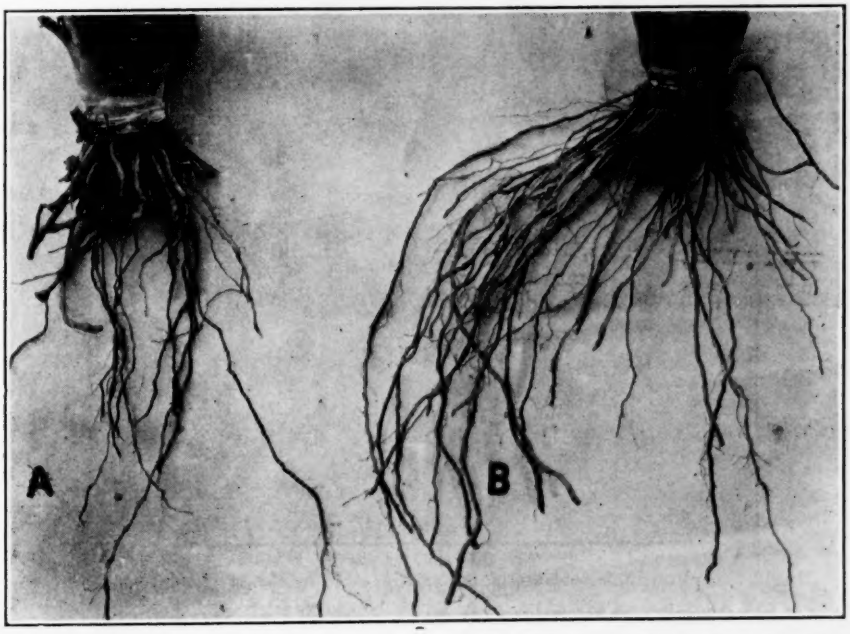


FIG. 2. A. Delayed heavy Heterodera infestation of the pineapple root system. Note that the first roots that developed were relatively free and that the plant became well established in the ground, but that the new roots are nearly all heavily infested. B. Plant of the same age, entirely free from infestation, shown for comparison. Greatly reduced.

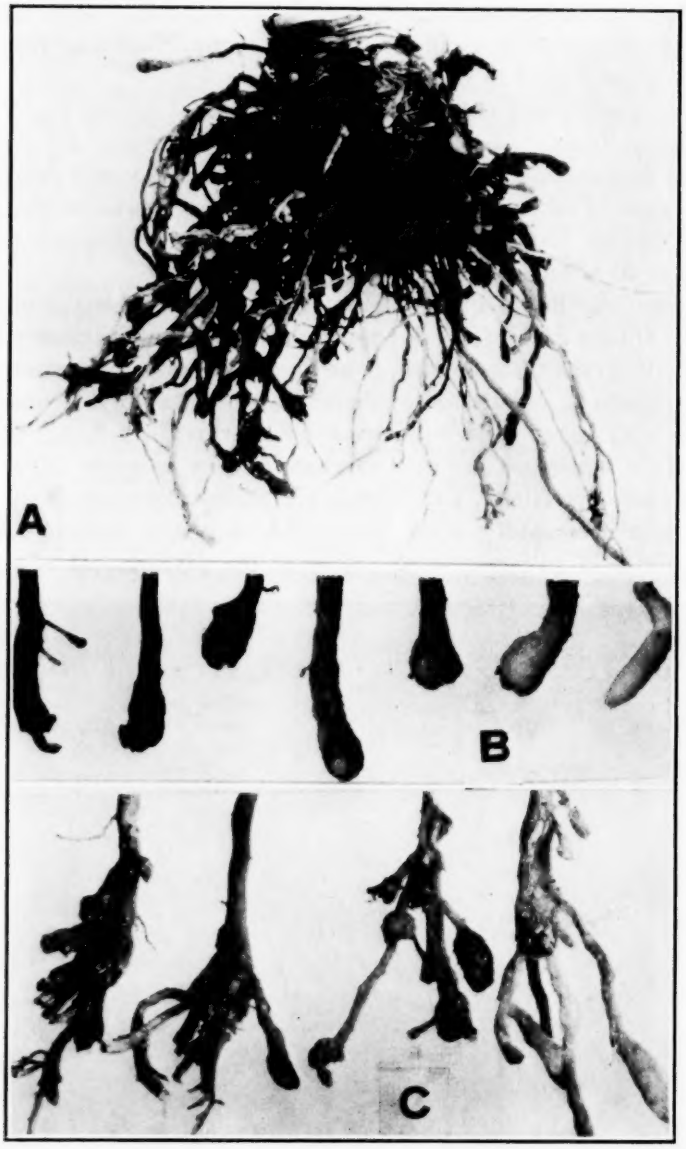


FIG. 3. A. Pineapple root system heavily infested by the two nematodes, *Heterodera marioni* and *Anguillulina pratensis*. The darkened roots and root tips are invaded by the Anguillulina in great abundance. B. and C. Typical pineapple root terminal galls: B, simple, and C, much branched, both types showing progressive stages of breakdown from right to left, due primarily to heavy invasion by *Anguillulina pratensis*. The normal reproduction of *Heterodera marioni* does not occur in such cases. A, greatly reduced; B and C, about natural size.

generations of nematodes, by virtue of the continued meristematic activity in the root.

SYMPTOMS OF ROOT KNOT IN THE PINEAPPLE PLANT

General symptoms of nematode root knot are well known, since most of the pertinent literature contains illustrations depicting them. In pineapple the symptoms are somewhat distinctive. Definite galls occur, but they are never so large and complex as those found in tomatoes and other vegetables and many field crops (13, *illus.*). The most evident signs of the disease are the club-shape terminal galls on the main roots, usually 3 or 4 times the diameter of the healthy root, and often somewhat flat on the end. Newly developed terminal galls are white at the tip, grading to yellowish and then the normal brown of the adult root. Old galls become brown throughout their length and often present a coarse network of lateral, or end cracks. Figures 1, 2, and 3 represent typical terminal galls. Frequently, in heavy soil infestation, 90 to 100 per cent of the roots show this symptom. Figure 1, A, illustrates a case of extreme infestation of the entire root system.

Main root terminal and non-terminal galls accompanied by frequent "brooming," and galls on branch rootlets, then, constitute the visible signs of the disease in the pineapple root system. The effects of such infection on the aerial portion of the plant are those commonly associated with root knot in general, *i.e.*, a dwarfing of plant growth, accompanied by a somewhat unhealthy color and some dying back of the leaves, and reduction in yield. These effects occur in proportion to the severity of infestation. Such symptoms, however, may result from a variety of causes. Therefore, above-ground condition of the plant is not, alone, a reliable criterion on which to base the presence or absence of nematode root knot. It must be added, however, that the experienced eye often can thus detect with a reasonable degree of certainty the heavily infested spots in a field. The sequence of developmental changes in a pineapple root system has been demonstrated by a series of experiments, here presented in detail, inasmuch as they, together with other specific observations, are basic to an explanation of what occurs during the life of the pineapple plant.

Besides the terminal galls, nonterminal fusiform enlargements occur on the roots, varying from slight irregular swellings in the woody roots to large distinct galls, somewhat smaller than the usual terminal galls. The smaller ones can not always be identified as such without dissecting the roots and finding the nematodes or the distinctive signs of nematodes having been present. Indeed, roots frequently are found that show no external evidence whatever, and that contain one or more mature females with egg masses, firmly imbedded in the tissues.

Another symptom associated with heavy infestation of the plant is an abnormally profuse branching of the roots approaching that of a broom formation. Figure 1, B and C, and figure 3, C, are typical cases of this, a condition resulting from cessation of growth of a root terminal with consequent stimulation of development in the region of branching back of the root tip. When the plant is still vigorous such branches often become as large as the original root terminal. Where soil infestation is heavy they soon become infected and cease growing, except as they produce several orders of new branches. The typical gall, however, must be sought as the distinctive sign of the nematode, for such "broom" effect may be caused by certain arthropods, by fertilizer injury of the root terminal, or other causes.

Still another symptom is the development of much smaller galls on branch rootlets. These are similar in appearance to those seen on small

FIG. 4. Small scattered primary infections in branch rootlets of a pineapple plant not yet showing any galls in the main roots. The protuberances, indicated by arrows, on the sides of the roots are Heterodera egg masses. *X*, surface of a spherical female nematode, the egg mass having become dislodged. Magnified about 4 diameters.

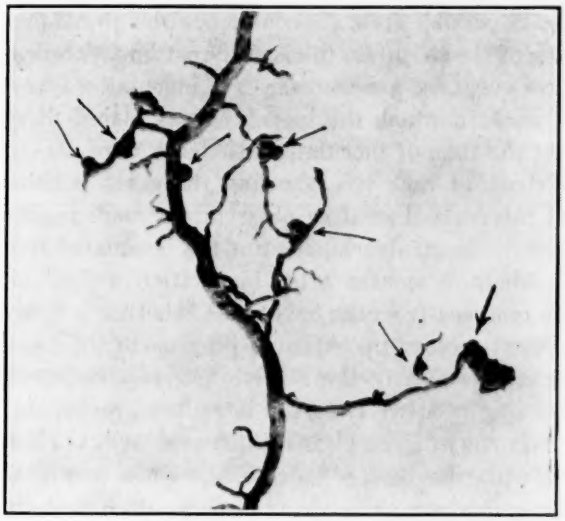


FIG. 5. A small portion of a branch rootlet of pineapple, with small galls and egg masses, (indicated by arrows), produced probably by the progeny of one or more generations, from a light original soil infestation. These galls are very small. If those shown in figures 1, B and 3, B and C were magnified to the same extent they would appear about 2 inches long. The new generation of nematodes evident here is sufficient in numbers to produce a terminal gall on a new main root. Magnified about 4 diameters.

roots of many of the common host plants of the nematode, such as *Begonia* sp., tobacco, and tomato, but are often overlooked in a superficial examination to determine presence or absence of infestation. They are about equally abundant as terminal and intercalary galls and are proportional to the size of the roots on which they occur, frequently being very small. Figures 4 and 5 are typical cases of such galls. In comparing these illustrations with those of main-root galls the difference in magnification should be taken into consideration.

INOCULATION EXPERIMENTS

Experiment 1

Relation of Position of Primary Inoculum to Primary Infection in an Individual Root and to Subsequent Progress of the Disease.—In January, 1931, small root-observation boxes (11) of sterilized soil were planted to slips of several different pineapple varieties. These become well established, as was manifest from root development visible through the glass sides of the boxes. Triplicate inoculations were then made at points 1, 2, and 3 inches to one side of a root terminal and $\frac{1}{2}$ inch below it, in the form of 5 recently collected egg masses at each point. The roots selected for inocula-

tion were as far as possible from the center in order to reduce the chance for closer proximity of the inoculum to another root buried beneath the surface. For comparative purposes, a second series of inoculations was made, usually replicated 10 times, in which the inoculum was placed directly at the tip of the root. At the time of inoculation, sketches were made to scale of the visible root systems of each box, showing the exact positions of the root terminals. At intervals thereafter observations were made and drawings inserted of the subsequent development of the inoculated roots and of new-grown roots. About 9 months after inoculation a final observation was made on plants removed from the boxes. At this time a complete gall count was made in order to record the extent of progress of the disease. Such final gall development was clearly the result of successive infections from the gradually spreading progeny from the introduced nematode eggs.

As the experiment progressed, it became evident that all conditions were not controlled with the desired adequacy. Slow availability of larvae, because of slow and irregular hatching of eggs, often made it possible for a particular root to grow away from the point of inoculation and thus escape early heavy infection. Complete absence of infective material from the rest of the box made this escape more probable. More definite results probably would have been obtained had enough newly hatched larvae instead of unhatched eggs been applied as inoculum. It is possible that watering may have moved the inoculum away from the point of application, though this movement could have occurred only after hatching. There was evidence that in 2 cases out of the 24 of 2- and 3-inch inoculations, another root was buried in the soil nearer than the marked root, thus vitiating otherwise fairly uniform results. For some unexplained reason, 21 of the 78 boxes inoculated were negative throughout for infection. Four out of 42 of these were in the direct-contact inoculation class, 5 of 12 in the 1-inch class, 4 of 12 in the 2-inch, and 8 of 12 in the 3-inch class. All of these were eliminated from the final analysis of results, though the percentages of positive infections were all in favor of the close inoculations.

Regardless of the unsatisfactory features of the test, which can be considered as alike for all lots, certain outstanding differences developed in percentages of inoculated roots showing early initial infection and in total infections produced at the end of the 9-month period. No striking differences between pineapple varieties were evident. For this reason and for the sake of simplifying the report, all are lumped together for the analysis of results (Table 1). Had the 2 exceptional cases, where the presence of a near-by buried root was indicated, been eliminated, the final main-root gall count for the 2- and 3-inch classes would have been 7 and 6, respectively, instead of 13 and 16.

TABLE 1.—*Relation to infection of pineapple roots by Heterodera marioni of position of inoculum with reference to root tips*

Distance of inoculum, inches	Number of plants	Early initial infections			Final infections, galls produced, (av. per box)	
		+	−	% +	Main roots	Branch rootlets
0	37	27	10	73	50	43
1	7	4	3	57	34	57
2	8	0	8	0	13	22
3	4	0	4	0	16	9

Plant-by-plant examinations led to other significant observations. In all cases there was early appearance of small galls on lateral rootlets, followed considerably later by infection of new roots. Roots inoculated directly at the tips showed a high percentage of early infection, whereas roots inoculated at points 2 or more inches away showed none whatever. In general, as shown by the table, plants in which early infection was visible had a significantly higher ultimate main-root gall count. The infections on branch rootlets clearly played an important part in building up the nematode populations. Superficial egg masses appeared abundantly on such rootlets, and the larvae released therefrom were largely responsible for the later infections in main roots. The final rootlet-gall count does not present the entire picture in this respect, for the rootlet system was constantly changing, and many of the early galls disappeared entirely before the final count was made.

Conclusions from this experiment are briefly as follows:

(1) A high percentage of early heavy infection of observed roots did not occur except where those roots grew within 1 inch of the point of inoculation. In other words there was not any striking chemotropic response of nematodes over a distance as great as 2 inches. Their movement appeared to be random, rather than directional.

(2) Early heavy infection of one or more roots was necessary to bring about relatively heavy infection of the entire root system within 9 months.

(3) Failure of heavy primary infection to occur permitted a scattering of the introduced nematode population, so that insufficient numbers were present at any one place for the production of early marked symptoms.

(4) Where the primary inoculation became scattered, any later infections resulted from scattered small infections on branch rootlets. These gradually built up a new population sufficient to infect large roots.

Experiment 2. *The Relation of Magnitude of Initial Inoculum to Development of Terminal Galls in Pineapple Roots.* In July, 1932, several root observation boxes of sterilized soil were planted to slips of Smooth Cayenne

pineapple. When the plants were well established, inoculations were made directly at root tips with counted numbers of newly hatched *Heterodera marioni* larvae, procured by the method described in another paper (16). Immediately after inoculation the exact positions of the ends of both inoculated and noninoculated roots were marked on the glass fronts. Thereafter daily observations were made on the extent of root growth, in millimeters. Progress of root-knot symptoms on individual roots also was noted. It was the objective of this experiment to determine the minimum number of larvae that would result in the stoppage of forward growth and the development of a terminal gall.

To make such a determination, it was necessary to fix upon a definition of a terminal gall that would meet the peculiar conditions of this particular experiment. Under actual field conditions, where there is abundant soil infestation, a root may encounter a constant supply of larvae, and thus be subject to continuous new invasions. Exactly this condition has been illustrated by Godfrey and Oliveira (20). Their figure 11, A, shows what is in all probability a true terminal gall, with newly invading larvae down to the very tip. In the present experiment the inoculum was placed in one spot only, directly on the root tip. If, by vigorous growth, the growing point were able to escape too copious invasion for a day or two, it would reach noninfested soil and then normally continue to grow, in spite of a temporary retardation, thus producing not a terminal, but a nonterminal gall. In taking the daily growth records in this experiment it was found that just this was taking place. While the rate of growth was greatly reduced by abundant infection, growth did continue; and, failing a continuous population of nematodes in advance of the root, it usually was resumed at a greater rate after a few days, or a branch root developed that continued growth without interruption. The average rate of growth of a normal, noninfected root was about 8 mm. per day. It was arbitarily decided that where the rate of an infected root was reduced to 2 mm. or less per day the resultant gall would be classed as terminal on the assumption that, had a continuous supply of larvae been present in the same degree of infestation the growth probably would have been stopped.

As with Experiment 1, certain irregularities occurred in this experiment, which required due allowance in preparing the tabulation of results. It was noted that, regardless of magnitude of inoculation, the first day's growth, in comparison with that of subsequent days, was always high. This verified the earlier observations of Godfrey and Oliveira (20) that the effect of infection is not manifest until after the first day. It was, therefore, necessary to eliminate the first day in calculating daily averages. As a rule, the following 7 days' growth was made the basis of calculations. Some roots were early observed to die from other causes. Some few, obviously clear excep-

tions, grew normally, or nearly so, without marked sign of infection, due perhaps to escape of the bulk of the larvae from the original site to other roots in the vicinity or to being washed away. Some roots, after inoculation, grew into the interior of the box, so that further observations were impossible. All such distinct exceptions are eliminated in the calculations. In none of the magnitude-of-inoculation classes was the number of cases sufficiently high to eliminate rather wide variations. Consequently, probable errors of the averages are high and differences are not so significant as might be expected with larger numbers.

The results of the experiment are presented in condensed form in table 2, where terminal galls as defined above are recorded. Nonterminal galls are those in which a distinct gall is evident, but growth was retarded only temporarily.

TABLE 2.—*Results of inoculations directly at pineapple root tips with counted numbers of Heterodera marioni larvae*

Series	Size of inoculum	Number of cases	Number discarded	Rate of growth per day mm.	Percentage with terminal galls	Percentage with nonterminal galls
I.	0	12	0	8.12 ± 0.25	0.0	0.0
	50	7	3	3.55 ± 0.48	28.6	14.3
	100	6	4	2.14 ± 0.54	50.0	50.0
	150	8	1	1.78 ± 0.26	62.5	25.0
	250	7	2	1.34 ± 0.27	85.7	14.3
	500	8	1	1.43 ± 0.36	85.7	14.3
	1000	3	0	1.12	100.0	
	2000	3	0	0.95	100.0	
	3000	3	0	0.75	100.0	
	4000	3	0	0.90	100.0	
	5000	5	0	1.38	100.0	
II.	0	5	0	8.0 ± 0.6	0.0	0.0
	100	6	0	2.88 ± 2.18	50.0	16.7
	150	6	1	2.24 ± 0.39	66.7	16.7
	200	4	1[a]	1.47 ± 0.20	100.0	0.0
	250	7	0	1.79 ± 0.14	50.0	50.0
	300	6	1[a]	1.30 ± 0.14	100.0	0.0

[a] Discarded because of almost complete escape from infection, as indicated by growth almost equal to that in the controls (6.7 mm. and 5.4 mm., respectively) due to some uncontrolled factor. All other cases listed were discarded because of their early death or of growth of tip into interior of box.

Examination of this table discloses that heavy retardation of root growth in 50 per cent or more of the cases, with virtual formation of terminal galls, occurred only in those classes in which the inoculum consisted of 100 or more

larvae. The differences in root growth in the classes of 100 and over are not statistically significant on the basis of present data, though the fair consistency of the gradual increase in percentage of roots showing terminal galls up to inoculations with 1000 larvae would make it appear that larger numbers of cases in the classes might make them so. The difference in growth between noninoculated controls and all inoculated classes is perfectly evident. That between the 50 class and the 300 class is $2.25 \pm .50$, the difference being $4\frac{1}{2}$ times its probable error. With the inoculations of higher magnitudes, 1000 and up, a superfluous population for the individual root was present, and sufficient numbers migrated to other roots, where early development of terminal galls occurred.

In this study with known populations of the root-knot nematode and their effects on pineapple roots, a number of difficulties have arisen, inherent in the small size of the organism and the lack of complete control possible with the equipment used, and these have made for lack of exactness in results. Among such difficulties are: (1) The difficulty of getting sufficiently large numbers of cases, for each population used, of active living larvae of the same age and vitality; (2) the difficulty of maintaining complete uniformity in soil moisture content about the root tips; (3) uncertainty as to uniformity in vigor of root growth; (4) lack of complete control in the matter of proximity of other roots; (5) difficulty in confining the larvae within uniformly controlled space limits at the point of inoculation. With continued effort on this problem some of these difficulties can be overcome and more exact results should be obtainable. It is impossible to obtain the degree of exactness of results reported by Chapman (7, 8) with *Tribolium confusum* Duval, for example, in which practically every individual could be accounted for.

Pertinent Data from Other Experiments. In the spring of 1932, 120 5-gallon (20 liter) wooden tubs of steam-sterilized soil, divided into 6 groups of 20 tubs each, were planted to pineapple slips. When the plants were well established, with roots from 1 to 2 inches long, they were inoculated with Heterodera larvae in quantities of 4, 20, 100, and 1000 to the plant, in 4 groups, the 5th group receiving 20 egg masses, or, potentially, about 8000 larvae, and the 6th serving as a control. The inocula were placed uniformly at one level, immediately proximate to the growing roots. At the age of 6 months there was no evident difference in plant growth between groups. In the light of the results from experiments 1 and 2, this is not surprising, since in two important respects the conditions did not meet with the requirements for immediate heavy infestation of the root system. In no case was the infective material uniformly distributed through the soil, thus many roots escaped early infection; and, even with most abundant inoculum, the magnitude of soil infestation averaged less than 10 larvae per cu. in., or

less than 1/10 the minimum number necessary for early and complete root infection.

In another experiment, reported by Collins and Hagan (10, 24), with Smooth Cayenne pineapples planted in tubs of 0.65 cu. ft. capacity, and inoculations of 500 egg masses (potentially 200,000 larvae), reduction in root length of 15.2 per cent and in plant weight of 29 per cent occurred, as compared with the controls. In this case, due probably to the fact that the nematodes were not uniformly distributed through the soil, many roots escaped complete stoppage in growth, but the final effect (at 8 months) on root and plant growth was nevertheless a substantial one.

Magistad and Oliveira (29) likewise show a very striking reduction in total root and plant growth brought about by a distinctly high population of nematodes.

These 3 supplementary experiments are reported as practical substantiation of the results to be expected in the light of the findings from experiments 1 and 2.

In another experiment, it was determined that the rate of spread of nematode infestation is very low in the root system of the pineapple plant. With well-established plants growing in sterilized soil, the end plant only was inoculated, in a row of plants spaced 12 inches apart. Seven months passed (with monthly observations) before infection was evident in the adjacent plant. Spread to only the third plant in the row had occurred by the 12th month. The spread in a row of cowpeas, with replantings when necessary, was 8 feet during the 12 months' period. The spread in both cases was by nematode motility and reproduction alone, mechanical agencies being eliminated.

CONSTANTLY CHANGING ROOT SYSTEM OF A PINEAPPLE PLANT AFFECTED BY NEMATODES

Progressive Changes Due to the Nematodes. Under the heading "Symptoms" in this paper a detailed description has been given of root knot in the pineapple plant. For any one plant the details of the picture are constantly changing. A root terminal with a newly developed gall may either continue to grow, resulting in a nonterminal gall, or it may enlarge to maximum size and remain permanently terminal. All nonterminal galls were originally terminal, as stated by Godfrey and Oliveira (20). The continuation or discontinuance of growth is determined by 3 factors, *viz.*, (a), numerical magnitude of the infection, *i.e.*, the number of larvae that have actually entered the growing root tip; (b), vigor of the plant and of root growth at time of infection; and (c) presence or absence of additional larvae in the soil below the root tip. Possibly also, as has been observed, the individual reaction of a root in the way of surface cracking, whether terminal or lateral,

is a factor. If lateral, continuation of root growth is more apt to occur. Some of the present terminal galls may, therefore, become nonterminal. A high proportion of nonterminal galls in any particular plant is usually an indication of vigorous root growth during the period of exposure, or of relatively light soil infestation.

The fact of continued root growth in the case of a nonterminal gall is proof that the root is functioning in the matter of continued movement of water upward from the soil and translocation of elaborated food downward to the root tip. The economy of the plant, therefore, is not greatly hampered. True terminal galls, then, are obviously the more injurious of the two, since they prevent normal root growth and thereby limit its feeding range. The very light infections that occur in main roots and that are scarcely detectable because of the hardening of the root tissues, without obvious gall formation, are virtually of no direct importance to the plant's economy.

Other changes constantly occur. Old roots die, and new ones grow from the axillary root primordia in the plant, and, where infestation is abundant they go through the same stages of gall development. Branch roots arise just above a terminal gall, and likewise may become infected. The branch rootlet system constantly varies. Once nematodes are numerously established in a root system, an actual *surplus* of larvae may be present in the soil at all times. In one experiment, heretofore reported (18), 11 successive plantings of a trap crop beside a heavily infested row of pineapples, each of which removed tremendous numbers of nematodes from the soil, produced no noticeable reduction in the amount of infestation in the pineapple plants, as compared with others in which trapping was not done. With such infestation, the root system presents much the same picture month after month, even though individual roots are constantly changing, unless some external agency has appeared that is capable of making a profound change in the nematode population.

Changes Brought About by Other Organisms. It is not to be expected that, under field conditions, a pure nematode population will be present to act without the influence of other organisms. Sideris (33) and Sideris and Paxton (34) have considered various fungi that kill pineapple root tips. In root study boxes, the writer has observed root tips initially penetrated by nematodes and showing early stages of gall development, later attacked by fungi and killed, completely preventing normal production of a new generation of nematodes. Entire fields have been observed in which terminal root galls become decayed, apparently soon after they are formed. Thousands of plants show the typical appearance of nematode infection (Fig. 1, A) with an abundance of short roots terminated by galls. Most of the galls, however, are brown and collapsed, the older ones being completely rotted internally, and the younger ones soft and watery. Histological examination of such

roots discloses the presence of a fungus permeating the tissues. Nematodes were doubtless the primary invaders, since the root-knot nematode is an obligate parasite and attacks only healthy roots. A tremendous change in normal nematode relations has been brought about by this secondary invader. If conditions, favorable for root growth and unfavorable to the fungus, soon recur, renewed plant growth may take place, with a much reduced nematode menace.

Again, the writer has observed in root-study boxes root terminals initially inoculated with nematodes and showing early stages of gall development, attacked before maturity of the contained nematodes by the larvae of a mycetophylid fly, *Sciara* sp., mentioned by Illingworth (27) as occasionally feeding upon healthy root tips. The result was a hole eaten into the side of the root tip, the hollowing of the tip, and the complete destruction of the nematodes. Healthy branch roots then developed and grew past the old terminal, without attack by nematodes. The garden Symphylid, *Scutigerella immaculata* Say likewise has been observed feeding upon galled root terminals and thereby preventing the propagation of a new generation of nematodes. The root-lesion nematode *Anguillulina pratensis* (de Man) Goffart (*Tylenchus brachyurus* Godfrey, 15) very definitely hastens the breakdown of a terminal gall, as shown in figure 3.

Many natural enemies of the nematode occur in pineapple-field soils. The writer has observed in root-study boxes of field soils a small brownish elongate active mite (species undetermined) actually feeding upon living larvae of *Heterodera marioni*. Dr. Hagan has observed this mite in great numbers in an experimental plot where the nematode was not reproducing so rapidly as was to have been expected in a continuous stand of susceptible cowpeas. Muir (30) has reported a fungus, later referred to (6) as *Microcera* sp., on Heterodera egg masses. The writer has found it in great abundance in garden and field soils, and has observed a large proportion of both eggs and newly hatched larvae dead in affected egg masses. Unfortunately, he did not have time to follow up his observations with extensive cultural studies. He also has found an undetermined protozoon parasitizing larvae. Species of the nematode genus Mononchus, known to be predators upon *Heterodera marioni*, are abundant in Hawaii, and particularly so in moist localities where the Heterodera was remarkably scarce. In laboratory studies, the writer has seen an entire group of 20 Heterodera larvae eaten or killed in a single night by one individual *Mononchus papillatus*. Cassidy (5) has described and pictured several species of the genus occurring in sugar-cane fields in Hawaii. Very possibly other natural enemies, not yet observed, occur in pineapple-field soils.

Complete studies of these organism complexes have not been made. It is certain, however, that they frequently influence very greatly the normal course of development of root knot in the pineapple root system.

The Influence of Environmental Conditions.—Environmental conditions play an important part in the survival of the nematode in the soil, and thereby influence the normal course of development of root knot in the pineapple field. Hoshino and Godfrey (26) have shown that the minimum lethal temperature for long exposures is about 41° C. Hagan (23) has determined that such lethal temperatures, sometimes much higher than 41° C., may occur under field conditions to a depth of at least 2 inches and sometimes even to 3 inches, thereby eliminating live nematodes from the upper layers of soil. Godfrey, Oliveira, and Gittel (21) have shown that soil moisture plays an important part in the longevity of the nematode. Under conditions of high relative humidity, which prevents drying, and low free water, which prevents activity, the nematodes may survive in the soil for many months. Under field conditions, this period of survival appears to be even longer than under the artificial conditions set up in their experiments, where survival for over 40 weeks was demonstrated. In long continued clean-fallow, field experiments indicator crop readings on the nematode population of the soil were taken at intervals. While very great reduction of the population was demonstrated, occasional plants continued to show live nematodes in the soil, even after 2 years, and a subsequent planting of pineapples, fairly free at first, later built up a distinct, though not very high, population. Some reinfestation from susceptible weeds was evident after the expiration of the first year. Some was apparently due as well to a heavy wash that occurred from an adjoining infested field. But it is believed that there was some survival of the original population in the deeper soil.

Temperature again plays an important part both in infection and in the length of life cycle of the root knot nematode. Godfrey (14) has given 13° C. as the approximate minimum at which any extensive infection will take place. Tyler (36) has shown that the length of life cycle is increased with the lowering of the temperature below the optimum for development, and decreased by raising the temperature within limits. Consequently, under field conditions, considerable variation in rate of development of the disease occurs, with fluctuations of temperature.

The simultaneous occurrence of other root-infesting organisms, the natural enemies of the nematode in the soil, and unfavorable environmental conditions, then, constitute certain "environmental resistances" that prevent the reproduction of the nematode to its full potential capacity. A major environmental resistance, however, has to do with the host plant itself. In the absence of a host plant the population constantly diminishes. Multiplication occurs only by infection and reproduction in the roots of a susceptible plant, whether it be weed or cultivated crop. Calculating each new egg mass as 400 potential larvae on the average (19, p. 43), only 0.5 per cent of potentially possible reproduction in a spot in the soil would serve to maintain the

population. For example, if any given volume of soil contained 2000 living eggs or larvae at a given time, only 10 of them reproducing to full capacity (granting half of them to be males) would bring the population back to 2000. Commonly the proportion of males is much less than $\frac{1}{2}$; indeed, Tyler (35) has shown that the presence of males is not essential to reproduction, so the potential rate of increase is even greater than that suggested. Again, it has been estimated that under optimum environmental conditions, with absolutely no environmental resistance present at any time (such as nonavailability of susceptible host tissues) the population in one year, starting with one nematode to the square foot, would be sufficient to make a solid layer of nematodes many miles thick over the surface of the field! Fortunately, the resistances come into active play with the first generation.

DISCUSSION

The experiments and observations give sufficiently exact information upon which to base the interpretation of field occurrence of root knot. In Hawaiian pineapple plantations 3 main degrees of plant infection, occurring over large areas, may be specified.

(1) *Early heavy infection* of the primary root system and continuous attack of new roots as they develop, resulting in an early dwarfing effect on plant growth and definite reduction in yield.

Experiments 1 and 2 show that a population of at least 100 larvae to the cubic inch, or 172,800 to the cubic foot, uniformly distributed through the soil, may be considered to be near the minimum number necessary to bring about certain early terminal gall formation on all the primary roots of a pineapple plant. This extent of infestation is not at all unusual in the field. A cowpea root, such as that shown in figure 2 of a previous paper (16), was potentially capable of releasing 80,000 larvae from each inch of its length. The entire root system would have released 1,600,000 larvae into less than a cubic foot of space. Owing to limited acreage with certain companies, pineapple plantings have been made shortly after plowing under a previous heavily infested crop, without the normal intercycle period for nematode reduction. Plantings also have been made following a highly susceptible rotation-crop legume, such as *Sesbania macrocarpa* Muhl. or rice bean (*Phaseolus calcaratus* Roxb.). In all such cases, as one might suspect, infestation of this classification occurs.

(2) *Early mild infection,* not plainly evident on the primary root system, with no marked effect on early plant growth, followed by what appears to be a sudden heavy attack on new roots at from 6 to 8 months after planting.

This type of infestation appears in plantings following an inadequate intercycle period or a rotation crop that has permitted the growth of nematode-susceptible weeds. The soil infestation is not of sufficient magnitude to

retard seriously the growth of the primary root system. The small branch rootlets become infested, however, (Figs. 4 and 5); and, through the course of 3 or 4 generations, they build up a sufficient population to produce terminal galls on the new roots. This accounts for the appearance of such a plant as that shown in figure 2, and for the so-called sudden appearance of infestation in a field that has earlier seemed to be relatively free.

(3) *Light, delayed infection*, with almost complete escape of the first set of roots, with vigorous plant growth and apparently undiminished plant-crop yield, followed by the gradual appearance of the usual root-knot symptoms in increasing abundance, and damage manifest in the ratoon crops.

This is the usual condition in pineapple fields that have received the full two-year rest period for nematode reduction, with clean fallow, or immune rotation crops. The nematodes have been greatly reduced, but not completely eliminated. There is very light infestation or none at all in the upper 6 or 8 inches of soil, and some survival in the deeper layers. The roots, then, must grow into this deeper soil before infection occurs. The course of development of the nematode population is much as in the preceding case, but considerably delayed.

SUMMARY

The normal pineapple root system consists of about 100 main roots of uniform size covered with branch rootlets.

The symptoms of root knot are club-shape, terminal galls; fusiform, non-terminal galls; a "brooming" of root terminals caused by the development of a number of branch roots, and abundant small galls on branch rootlets. Large compound galls do not occur, as they do with most other crops.

The individual details of root galls are constantly changing because of decay of old galls and the development of new axillary roots.

Other root-infesting organisms, including root-rotting fungi and various fauna, play an important part in the changing root-knot situation.

The magnitude and location of primary soil infestation determine whether or not serious initial damage occurs. Experiments show that infestation of the magnitude of at least 100 active larvae located directly at the root tip is necessary to stop the growth of a vigorous root and produce a terminal gall.

Any plant in which essentially every primary root has been stopped by a terminal gall may be considered to have been planted in soil with an initial infestation of at least 100 larvae per cubic inch, or 172,800 larvae per cubic foot, fairly uniformly distributed through the soil.

Where primary infestation is distinctly less than this, many of the roots escape serious injury and the plants become well established. In such cases, however, in later stages of plant growth, heavy infection may occur as the result of the gradual building up of a high nematode population from pri-

mary infections in branch rootlets and small roots. This results in the very common condition of long main roots relatively free from infection, and new short axillary roots heavily infected.

Heavy infection of the initial roots from the start results in dwarfed plant growth, greatly reduced yield, and early failure of ratoons. Delayed heavy infection permits of good initial root and plant growth and good plant-crop yield, with subsequent yields dependent upon the magnitude of the nematode population that develops.

External agencies, not yet thoroughly studied, may vitiate the uniformity of this normal course of the relationship of nematodes to the pineapple plant.

LITERATURE CITED

1. BARRETT, O. W. The tropical crops. 445 pp. Macmillan Co., New York. 1928.
2. BESTER, R. A. Pineapple culture in South Africa. 20 pp. The Specialty Press of South Africa, Ltd., Johannesburg. Cape Town. [Date lacking.]
3. BOWERS, F. A. I. The root system of pineapple plants. Assoc. Hawaiian Pineapple Canners Expt. Sta. (University of Hawaii) Bull. 12. 1929.
4. BRUTTINI, A. Cultivazione delle piante tropicali. (Nuovo Enciclopedia Agraria Italiana, pt. 5). 51 pp. Unione Tipografico editrice torinese. Torina. 1924.
5. CASSIDY, GERTRUDE. Some Mononchs of Hawaii. Hawaiian Planters' Record **35**: 305–339. 1931.
6. CASSIDY, G. H., and R. H. VAN ZWALUWENBURG. Nematodes in relation to growth failure of sugar cane in Hawaii. Assoc. Hawaiian Sugar Technol. Rept. **6**: 10–15. 1927.
7. CHAPMAN, R. N. The quantitative analysis of environmental factors. Ecology **9**: 111–122. 1928.
8. ————, and L. BAIRD. The biotic constants of *Tribolium confusum* Duval Jour. Expt. Zool. **68**: 293–304. 1934.
9. COBB, N. A. Fungus maladies of the sugar cane. Hawaiian Sugar Planters' Assoc. Expt. Sta. Div. Path. and Physiol. Bull. 6. 1909.
10. COLLINS, J. L., and H. R. HAGAN. Nematode resistance of pineapples. Varietal resistance of pineapple roots to the nematode *Heterodera radicicola* (Greef) Müller. Jour. Heredity **23**: 459–465, 503–511. 1932.
11. DEAN, A. L. Root observation boxes. Phytopath. **19**: 407–412. 1929.
12. FENZI, E. O. Frutti tropicali e semitropicali. 261 pp. Istituto agricolo coloniale italiano. Firenzi. 1915.
13. GODFREY, G. H. Root-knot: its cause and control. U. S. Dept. Agr. Farmers' Bull. 1345. 1923.
14. ————. Effect of temperature and moisture on nematode root-knot. Jour. Agr. Research [U. S.] **33**: 223–254. 1926.
15. ————. A destructive root disease of pineapples and other plants due to *Tylenchus brachyurus* n. sp. Phytopath. **19**: 611–629. 1929.
16. ————. Some technique used in the study of the root-knot nematode, *Heterodera radicicola*. Phytopath. **21**: 323–329. 1931.
17. ————. Experiments on the control of the root-knot nematode in the field with chloropicrin and other chemicals. Phytopath. **25**: 67–90. 1935.

18. GODFREY, G. H., and H. R. HAGAN. A study of the root-knot nematode trap crop under field soil conditions. Phytopath. **24**: 648–658. 1934.
19. ————————, and H. M. HOSHINO. Studies on certain environmental relations of the root-knot nematode, *Heterodera radicicola*. Phytopath. **23**: 41–62. 1933.
20. ————————, and J. OLIVEIRA. The development of the root-knot nematode in relation to root tissues of pineapple and cowpea. Phytopath. **22**: 325–348. 1932.
21. ————————, J. M. OLIVEIRA, and E. B. H. GITTEL. The duration of life of the root-knot nematode *Heterodera radicicola* in soils subjected to drying. Soil Sci. **35**: 185–195. 1933.
22. HAGAN, H. R. Comparisons in the distribution of nematode galls on the roots of pineapple varieties attacked by the nematode *Heterodera radicicola* (Greef) Müller. Soil Sci. **35**: 29–42. 1933.
23. ————————. Hawaiian pineapple field soil temperatures in relation to the nematode *Heterodera radicicola* (Greef) Müller. Soil Sci. **36**: 83–95. 1933.
24. ———————— and J. L. COLLINS. Studies on varietal resistance of pineapple plants. Pt. II. Plant resistance to *Heterodera marioni* (Cornu) Goodey. Jour. Heredity **26**: 35–46. 1935.
25. HENRICKSON, H. C. Pineapple growing in Porto Rico. Porto Rico Agr. Expt. Sta. Bull. 8. 1909.
26. HOSHINO, H. M., and G. H. GODFREY. Thermal death point of *Heterodera radicicola* in relation to time. Phytopath. **23**: 260–270. 1933.
27. ILLINGWORTH, J. F. Pineapple insects and some related pests. Assoc. Hawaiian Pineapple Canners Expt. Sta. (University of Hawaii) Bull. 9. 1926.
28. JOHNSON, M. O. The pineapple. 306 pp. Paradise of the Pacific Press. Honolulu, Hawaii. 1935.
29. MAGISTAD, O. C., and J. M. OLIVEIRA. Changes in plant-food intake caused by a population of *Heterodera marioni* (Cornu) Goodey on *Ananas comosus*. Phytopath. **24**: 276–283. 1934.
30. MUIR, [F. A. G.] [Fungus parasitic on nematodes.] Hawaiian Sugar Planters' Assoc. Proc. **46**: 87. 1926.
31. NOTER, R. DE. Le verger coloniale. Guide pratique à l'usage des colons des pays chauds. 176 pp. Société D'éditions gêographique maritimes et coloniales. Paris. 1925.
32. SEMLER, H. Die tropische Agrikultur. 2 Aufl. 3 Bde. Wismar Hinstorff'sche Hofbuchhandlung Verlagsconto. 1897–1903.
33. SIDERIS, C. P. Pathological and histological studies on pythiaceous root rots of various agricultural plants. Phytopath. Ztschr. **3**: 137–161. 1931.
34. ————————, and G. E. PAXTON. Pathological, histological, and symptomatological studies on pineapple root rots. Amer. Jour. Bot. **18**: 465–498. 1931.
35. TYLER, J. Reproduction without males in aseptic root cultures of the root-knot nematode. Hilgardia **7**: 373–388. 1933.
36. ————————. Development of the root knot nematode as affected by temperature. Hilgardia **7**: 391–415. 1933.
37. VOSBURY, E. D., and J. R. WINSTON. Pineapple culture in Florida. U. S. Dept. Agr. Farmers' Bull. 1237. 1921.
38. WOHLTMANN, F. Handbuch der tropischen Agrikultur. 1. Bd. Duncker & Humbolt. Leipzig. 1892.

FLAX SEED-TREATMENT TESTS[1]

H. H. Flor[2]

(Accepted for publication May 20, 1935)

INTRODUCTION

Seed treatment for flax, for the control of certain seed-borne diseases such as seedling-blight or canker, *Colletotrichum lini* Bolley, and wilt, *Fusarium lini* Bolley, has been advocated since 1910 (1). The formaldehyde-spray treatment was the one most widely recommended but its use never became general. The mucilaginous nature of the flax seed coat made it difficult to apply the formaldehyde solution thoroughly enough to disinfect the seed without the latter becoming sticky and hard to handle. Also, experimental data on the effect of seed treatment on stand, yield, and prevalence of diseases of flax was limited. The discovery and use of seed disinfectants in powdered form has renewed the interest of investigators in flax seed-treatment tests. Schilling (6, 7), Medish and Raro (5), and Eglits (3) have secured an increase in quantity and quality of flax straw and, in some cases, an increase in yield of seed by treating with fungicidal dusts. The most beneficial effects were obtained when seed of inferior quality was used or when seedling diseases were prevalent. Burnett and Reddy (2) obtained beneficial results with the Ceresan dust treatment in 1 year's trials at a number of localities in Iowa. On the other hand, Kletschetoff (4) tested 134 seed disinfectants, including those reported most beneficial by other investigators (3, 6, 7), and found that none gave satisfactory results.

The cooperative tests reported in this paper were initiated to determine the effect of treatment of flax seed on stand, yield, and incidence of disease in the different sections of the principal seed-flax producing area of the United States.

The investigators cooperating in these tests and the stations at which seed-treatment tests were conducted are as follows:

C. C. Allison,
Minnesota Agricultural Experiment Station,
St. Paul, Minn.

R. O. Bridgford,
West Central Experiment Station,
Morris, Minn.

R. E. Hodgson,
Southeast Experiment Station,
Waseca, Minn.

H. E. Morris,
Montana Agricultural Experiment Station,
Bozeman, Mont.

[1] Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the North Dakota Agricultural Experiment Station.

[2] Associate pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

R. W. Smith,
Dickinson Substation,
Dickinson, N. Dak.

O. A. Thompson,
Edgeley Substation,
Edgeley, N. Dak.

E. H. Flor,
North Dakota Agricultural Experiment Station,
Fargo, N. Dak.

C. H. Plath,
Hettinger Substation,
Hettinger, N. Dak.

Glenn S. Smith,
Langdon Substation,
Langdon, N. Dak.

J. C. Brinsmade, Jr.,
United States Northern Great Plains Field Station,
Mandan, N. Dak.

K. H. Klages,
South Dakota Agricultural Experiment Station,
Brookings, S. Dak.

The curtailment of budgets and crop failures due to drought restricted the tests at a number of the stations to 1 year's results. Altogether, seed-treatment data were secured from tests involving 57 different dates of sowing.

MATERIALS AND METHODS

The seed used in these tests was from the preceding year's crop grown at Fargo, N. Dak. It was uniformly treated at Fargo, packaged in envelopes for rod-row seeding, and distributed to the individual cooperators shortly before time for sowing. The standard plot of 3 rod rows was used in these tests, and stand and yield data were obtained from the center row of each plot. In 1931, 1933, and 1934 four plots for each treatment were used, and the 1932 tests had but three plots for each treatment. In 1931, two varieties, Bison (C. I. 389),[3] wilt-resistant, and Damont (C. I. 3), wilt-susceptible, were sown during the period recommended for flax seeding at each station. In 1932, 1933, and 1934 only the Bison variety was used and three sowings were made at each station at intervals of about 2 weeks. In 1931 and 1932, the following three treatments were used: (1) The formaldehyde-spray treatment, in which the seed was sprayed with a 1 to 320 solution of commercial formaldehyde at the rate of 1 gallon per bushel, covered over night and then dried; (2) the copper carbonate dust treatment; and (3) the Ceresan (ethyl mercuric chloride) dust treatment. The copper carbonate and Ceresan were each applied at the rate of 4 ounces per bushel. Copper carbonate dust, containing 50 to 52 per cent of metallic copper, was used. In 1933, the formaldehyde treatment was dispensed with at the cooperating stations because of injury resulting from delayed sowing. In the 1933 and 1934 tests at Fargo, the formaldehyde-spray treatment was applied the day prior to sowing. The individual cooperators were not specifically

[3] C. I. refers to accession number of the Division of Cereal Crops and Diseases.

requested to make accurate stand counts because it would have required considerable labor at a busy season of the year. However, stand data were taken at a number of stations, and these together with data on yield are given in table 1.

EXPERIMENTAL RESULTS

The failure of any treatment to be decidedly beneficial either to stand or yield is clearly indicated in table 1. The most conspicuous effect of the treatments was the injury that resulted from the use of formaldehyde. This was more pronounced on stand than on yield. Stand counts were obtained from 24 tests in which the effect of the formaldehyde, Ceresan, and copper carbonate treatments and the non-treated check were compared. The stand of plots sown with non-treated seed and seed treated with Ceresan and copper carbonate was better than that of plots sown with formaldehyde-treated seed in 21 tests each; the stand of plots sown with formaldehyde-treated seed was better than that of those sown with non-treated seed in 2 tests and equal in 1 test, and was better than that of plots sown with seed treated with Ceresan and copper carbonate in 3 tests each. The stand of plots sown with Ceresan-treated seed was better than that of plots sown with non-treated seed in 18 out of 28 tests and better than the stand of those sown with copper carbonate-treated seed in 16 out of 28 tests. Plots sown with non-treated seed had superior stand counts to those sown with copper carbonate-treated seed in 15 out of 28 tests.

The effects of the treatments on yield were more variable than were those on stand and the injurious effect of the formaldehyde treatment was less pronounced. There were 47 tests in which the average yield of plots sown with formaldehyde-treated seed was compared with that of plots sown with non-treated seed and seed dusted with Ceresan and copper carbonate. In 15 tests the average yield from plots sown with formaldehyde-treated seed was greater than that from those sown with non-treated seed, and in 32 tests it was less. In 15 tests, plots sown with formaldehyde-treated seed yielded more than those sown with seed dusted with Ceresan; in 30 tests, they yielded less; and in 2 tests, the yields were identical. In 12 tests, plots sown with formaldehyde-treated seed yielded more than those sown with copper carbonate-treated seed; in 34 tests they yielded less, and in 1 test, the yields were identical. There were 55 tests in which the yield of plots sown with non-treated seed was compared with that of plots sown with seed treated with Ceresan and copper carbonate. In 28 tests, the plots sown with Ceresan-treated seed yielded more than those sown with non-treated seed; in 23 tests they yielded less; and in 4 tests, the yields were identical. The plots sown with seed treated with copper carbonate yielded more than those sown with non-treated seed in 27 tests, in 22 tests they yielded less, and in 6 tests the

TABLE 1.—*Effect of treating flax seed on yield and stand at 11 stations in Minnesota, North Dakota, South Dakota, and Montana from 1931–34*

Station	Variety	C. I. no.	Date sown	Stand in plants per rod row				Yield in bushels per acre			
				Non-treated check	Treated with			Non-treated	Treated with		
					Formaldehyde spray	Ceresan dust	Copper carbonate dust		Formaldehyde spray	Ceresan dust	Copper carbonate dust
Bozeman, Mont.	Bison	389	1931	.....	.....	.....	.....	12.7 ± 1.29	10.7 ± 1.08	10.0 ± 1.01	9.9 ± 1.00
	Damont	3	1931	.....	.....	.....	.....	11.6 ± 1.34	8.4 ± 0.97	11.3 ± 1.30	12.3 ± 1.42
			1932								
	Bison	389	May 10	.....	.....	.....	.....	[a]13.6 ± 1.43	[a]13.2 ± 1.39	[a]9.8 ± 1.03	[a]16.4 ± 1.73
	Do	389	May 24	.....	.....	.....	.....	12.6 ± 0.69	10.0 ± 0.55	12.6 ± 0.69	11.1 ± 0.61
	Do	389	June 4	.....	.....	.....	.....	9.1 ± 0.47	6.1 ± 0.32	9.8 ± 0.51	10.1 ± 0.53
Brookings, S. Dak.	Bison	389	May 2	[b]99 ± 1.8	[b]73 ± 1.3	[b]98 ± 1.8	[b]105 ± 1.9	8.8 ± 0.49	7.7 ± 0.43	8.6 ± 0.48	10.5 ± 0.59
	Do	389	May 17	[b]123 ± 3.3	[b]89 ± 2.4	[b]125 ± 3.4	[b]115 ± 3.1	3.5 ± 0.17	2.6 ± 0.13	4.4 ± 0.22	3.9 ± 0.19
Dickinson, N. Dak.	Bison	389	May 7	.....	.....	.....	.....	10.7 ± 0.80	7.2 ± 0.54	12.2 ± 0.92	12.9 ± 0.97
	Do	389	May 20	.....	.....	.....	.....	10.4 ± 0.46	7.0 ± 0.31	10.6 ± 0.47	10.1 ± 0.45
	Do	389	June 1	.....	.....	.....	.....	11.8 ± 1.26	7.8 ± 0.84	11.0 ± 1.18	8.4 ± 0.90
Edgeley, N. Dak.	Bison	389	1931	.....	.....	.....	.....	10.3 ± 0.70	10.7 ± 0.73	11.6 ± 0.79	11.9 ± 0.81
	Damont	3	1931	.....	.....	.....	.....	9.4 ± 0.73	9.7 ± 0.76	9.6 ± 0.75	12.0 ± 0.94
			1931								
Fargo, N. Dak. (farm soil)	Bison	389	May 16	.....	.....	.....	.....	13.9 ± 0.33	13.8 ± 0.33	14.0 ± 0.34	14.5 ± 0.35
	Damont	3	May 16	.....	.....	.....	.....	11.5 ± 0.69	12.8 ± 0.77	12.1 ± 0.73	13.2 ± 0.79
			1932								
	Bison	389	May 2	755 ± 39.0	435 ± 22.6	766 ± 39.8	716 ± 37.2	17.9 ± 0.77	16.4 ± 0.71	16.8 ± 0.72	17.4 ± 0.75
	Do	389	May 19	741 ± 24.2	482 ± 15.7	720 ± 23.6	764 ± 25.0	16.9 ± 0.41	15.9 ± 0.38	17.2 ± 0.41	17.1 ± 0.41
	Do	389	June 14	572 ± 25.6	321 ± 14.5	602 ± 27.0	577 ± 26.0	10.9 ± 0.72	9.9 ± 0.65	11.5 ± 0.76	11.9 ± 0.79
			1933								
	Do	389	May 2	708 ± 19.8	602 ± 16.8	726 ± 20.3	749 ± 21.0	13.0 ± 0.31	13.5 ± 0.32	14.9 ± 0.36	14.7 ± 0.35
	Do	389	May 15	683 ± 17.1	619 ± 15.5	633 ± 15.7	648 ± 16.2	16.9 ± 0.80	16.8 ± 0.79	17.4 ± 0.82	14.8 ± 0.70
	Do	389	June 2	.....	.....	.....	.....	6.6 ± 0.30	6.7 ± 0.30	6.4 ± 0.29	6.2 ± 0.28
			1934								
	Do	389	April 28	111 ± 7.8	112 ± 7.8	138 ± 9.7	97 ± 6.8	4.8 ± 0.37	5.2 ± 0.39	4.1 ± 0.31	4.8 ± 0.37
	Do	389	May 12	625 ± 11.9	562 ± 10.7	650 ± 12.3	608 ± 11.5	1.6 ± 0.44	1.0 ± 0.27	1.9 ± 0.52	2.2 ± 0.60
	Do	389	May 26	568 ± 10.8	496 ± 9.4	561 ± 10.7	575 ± 10.9	4.2 ± 0.44	5.0 ± 0.53	4.5 ± 0.47	4.5 ± 0.47

TABLE 1.—(*Continued*).

Station	Variety	C. I. no.	Date sown	Stand in plants per rod row				Yield in bushels per acre			
				Non-treated check	Treated with			Non-treated	Treated with		
					Formaldehyde spray	Ceresan dust	Copper carbonate dust		Formaldehyde spray	Ceresan dust	Copper carbonate dust
			1931								
Fargo, N. Dak. (wilt-sick soil)	Bison	389	May 12	.....	.....	.....	.....	9.3 ± 0.49	9.7 ± 0.52	9.0 ± 0.48	8.6 ± 0.46
	Damonte	3	May 12	.....	.....	.....	.....	.....	.....	.....	.....
			1932								
	Bison	389	May 13	284 ± 16.7	206 ± 12.2	329 ± 19.4	279 ± 16.4	6.7 ± 0.48	6.2 ± 0.45	8.0 ± 0.58	8.6 ± 0.62
			1933								
	Do	389	May 12	544 ± 27.2	470 ± 23.5	469 ± 23.4	496 ± 24.8	11.7 ± 0.84	11.1 ± 0.80	11.1 ± 0.80	10.8 ± 0.78
			1934								
	Do	389	April 28	285 ± 19.1	248 ± 16.6	328 ± 22.0	273 ± 18.3	11.7 ± 0.75	11.8 ± 0.75	12.2 ± 0.78	11.9 ± 0.76
	Do	389	May 12	492 ± 27.6	450 ± 25.2	408 ± 22.8	436 ± 24.4	5.7 ± 0.39	6.1 ± 0.42	5.5 ± 0.38	5.7 ± 0.39
	Do	389	May 26	496 ± 25.8	385 ± 21.2	508 ± 28.0	519 ± 28.6	5.4 ± 0.51	5.5 ± 0.52	5.2 ± 0.49	5.2 ± 0.49
			1931								
Hettinger, N. Dak.	Bison	389	May 16	.....	.....	.....	.....	4.7 ± 0.22	4.1 ± 0.19	3.9 ± 0.18	3.8 ± 0.17
	Damont	3	May 16	.....	.....	.....	.....	4.6 ± 0.38	4.2 ± 0.35	4.2 ± 0.35	4.3 ± 0.36
			1931								
Langdon, N. Dak.	Bison	389	May 14	.....	.....	.....	.....	15.0 ± 1.51	11.5 ± 1.16	16.8 ± 1.70	16.8 ± 1.70
	Damont	3	May 14	.....	.....	.....	.....	11.4 ± 0.98	13.0 ± 1.12	12.4 ± 1.07	15.9 ± 1.37
			1932								
	Bison	389	May 10	.....	.....	.....	.....	14.9 ± 0.41	13.8 ± 0.38	13.6 ± 0.37	14.7 ± 0.40
	Do	389	May 25	.....	.....	.....	.....	12.7 ± 0.90	9.7 ± 0.69	15.5 ± 1.10	12.7 ± 0.90
	Do	389	June 10	.....	.....	.....	.....	3.8 ± 0.48	1.9 ± 0.24	3.7 ± 0.46	2.9 ± 0.36
			1933								
	Do	389	May 5	.....	.....	.....	.....	4.0 ± 0.54	.....	6.6 ± 0.89	3.7 ± 0.50
	Do	389	May 19	.....	.....	.....	.....	6.2 ± 0.71	.....	6.1 ± 0.70	6.4 ± 0.74
	Do	389	June 15	.....	.....	.....	.....	4.7 ± 0.56	.....	3.9 ± 0.47	3.7 ± 0.45

TABLE 1.—(*Continued*).

Station	Variety	C. I. no.	Date sown	Stand in plants per rod row				Yield in bushels per acre			
				Non-treated check	Treated with			Non-treated	Treated with		
					Formaldehyde spray	Ceresan dust	Copper carbonate dust		Formaldehyde spray	Ceresan dust	Copper carbonate dust
Mandan, N. Dak.	Bison	389	1931	.....	.....	.....	.....	12.3 ± 0.33	13.0 ± 0.35	13.4 ± 0.36	13.4 ± 0.36
	Damont	3	1931	.....	.....	.....	.....	12.0 ± 0.76	12.7 ± 0.80	10.9 ± 0.69	13.1 ± 0.83
			1932								
	Bison	389	May 2	[d]1670 ± 123.3	[d]715 ± 52.8	[d]1466 ± 108.3	[d]1521 ± 112.6	17.0 ± 0.54	14.1 ± 0.45	16.7 ± 0.53	16.2 ± 0.52
	Do	389	May 16	[d]1212 ± 40.0	[d]965 ± 31.8	[d]1183 ± 39.0	[d]1053 ± 34.8	12.6 ± 0.29	12.2 ± 0.28	12.4 ± 0.29	11.7 ± 0.27
	Do	389	June 3	[d]1143 ± 33.2	[d]548 ± 15.9	[d]1183 ± 34.4	[d]1016 ± 29.4	9.4 ± 0.28	8.1 ± 0.24	9.5 ± 0.28	9.5 ± 0.28
			1933								
	Do	389	May 2	[d]1533 ± 43.6	.....	[d]1535 ± 43.7	[d]1598 ± 45.4	2.9 ± 0.16	.....	3.2 ± 0.17	3.3 ± 0.18
	Do	389	May 16	[d]1623 ± 71.5	.....	[d]1577 ± 69.4	[d]1503 ± 66.2	2.8 ± 0.09	.....	2.8 ± 0.09	2.8 ± 0.09
	Do	389	June 1	[d]999 ± 42.0	.....	[d]1141 ± 47.9	[d]1064 ± 44.7	0.8 ± 0.22	.....	0.8 ± 0.22	0.8 ± 0.22
Morris, Minn.	Bison	389	1931	.....	.....	.....	.....	6.1 ± 0.94	5.7 ± 0.88	6.4 ± 0.99	6.1 ± 0.94
	Damont	3	1931	.....	.....	.....	.....	1.6 ± 0.40	0.9 ± 0.22	1.7 ± 0.43	1.5 ± 0.38
St. Paul, Minn. (farm soil)	Bison	389	1931	285 ± 14.5	255 ± 13.0	318 ± 16.2	258 ± 13.2	4.4 ± 0.40	4.1 ± 0.37	4.4 ± 0.40	4.1 ± 0.37
	Damont	3	1931	50 ± 6.8	50 ± 6.8	71 ± 9.7	69 ± 9.4	0.9 ± 0.15	0.8 ± 0.13	1.3 ± 0.21	1.1 ± 0.18
St. Paul, Minn. (wilt-sick soil)	Bison	389	1931	310 ± 20.7	341 ± 22.8	319 ± 21.3	309 ± 20.6	5.3 ± 0.22	6.2 ± 0.25	5.3 ± 0.22	4.8 ± 0.20
	Damont[c]	3	1931	.....	.....	.....	.....				
			1932								
	Bison	389	May 3	453 ± 31.2	151 ± 10.4	629 ± 43.4	623 ± 42.9	12.2 ± 0.80	5.8 ± 0.38	14.3 ± 0.94	13.4 ± 0.89
	Bison	389	May 22	497 ± 19.9	199 ± 8.0	557 ± 22.3	604 ± 24.2	[e]	[e]	[e]	[e]
			1933								
	Bison	389	May 6	456 ± 9.6	.....	645 ± 13.5	655 ± 13.7	7.6 ± 0.23	.....	8.9 ± 0.27	8.7 ± 0.27
	Bison	389	May 16	.....	.....	.....	.....	2.6 ± 0.27	.....	2.2 ± 0.23	2.1 ± 0.22
Waseca, Minn.	Bison	389	1932	176 ± 7.6	39 ± 1.7	311 ± 13.3	239 ± 10.3				

[a] Yield from 8 foot row. [b] Number of plants in 4 feet of row. [c] Completely killed by wilt. [d] No. of plants per A. (000 omitted).
[e] Adverse climatic conditions destroyed the crop from this and later sowings.

yields were equal. In 27 tests, the plots sown with Ceresan-treated seed yielded more than those sown with seed treated with copper carbonate; in 21 tests, they yielded less; and in 7 tests the yields were identical.

TABLE 2.—*Summary of the statistical analysis of the results of flax seed-treatment tests at 11 stations in Minnesota, North Dakota, South Dakota, and Montana*

		Number of tests in which statistically significant differences in stand or yield were obtained between the treatments compared											
No. of tests in which treatments were compared	No. of tests in which there was no significant difference between any of the treatments	Check better than formaldehyde	Check better than Ceresan	Check better than copper carbonate	Formaldehyde better than check	Formaldehyde better than Ceresan	Formaldehyde better than copper carbonate	Ceresan better than check	Ceresan better than formaldehyde	Ceresan better than copper carbonate	Copper carbonate better than check	Copper carbonate better than formaldehyde	Copper carbonate better than Ceresan
						Stand							
24	6	15	.....	.....	0	0	0	.....	17	.....	.....	15	.....
28	9	.....	0	2	.....	.....	.....	3	.....	3	4	.....	0
						Yield							
47	31	9	.....	.....	0	0	1	.....	11	.....	.....	9	.....
55	38	.....	0	1	.....	.....	.....	1	.....	1	1	.....	1

The statistical analysis of the results at all cooperating stations, a summary of which is given in table 2, brings out more clearly the variability of the results and the general failure of the treatments to benefit either stand or yield. The formaldehyde treatment was included in 18 of the 19 tests in which significant differences in stand were obtained. In 17 of these 18 tests, the stand from the Ceresan-treated seed, and in 15 tests each, the stand from the copper carbonate-treated and the non-treated check seed was significantly greater than that from the seed receiving the formaldehyde treatment. The 4 tests in which either or both Ceresan and copper carbonate dust treatments gave significantly better stands than the non-treated check were at St. Paul and Waseca, Minn., stations at the edge of the present seed-flax producing region.

The wilt-susceptible variety, Damont, was included only in the 1931 tests. It was sown on farm soil at all the cooperating stations, and at St. Paul, Minn., and Fargo, N. Dak.; additional sowings were made on wilt-infested soil. No treatment had a noticeable effect on the occurrence of wilt in this variety and no significant differences in yield were obtained. Stand counts

were made only at St. Paul but there were no significant differences between the treatments.

The effect of the different seed treatments on yield resembled that on stand, except that injury due to the formaldehyde treatment was less pronounced. In 38 of the 55 tests in which yield data were obtained, there were no significant differences in yields between any of the treatments. In only 1 of the 55 tests were the yields from plots sown with treated seed significantly greater than the yield from those sown with non-treated seed. This was the first date-of-sowing test on farm soil at Fargo, N. Dak., in 1933, in which the probable error was small, and the plots sown with seed treated with Ceresan and copper carbonate yielded more than those sown with non-treated seed by significant amounts. One instance in which the non-treated seed yielded more than that treated with copper carbonate, one in which the Ceresan-treated yielded more than the copper carbonate-treated, one in which the copper carbonate-treated yielded more than the Ceresan-treated, and one in which the formaldehyde-treated yielded more than the copper carbonate-treated by significant amounts were also recorded. The formaldehyde treatment was included in 47 of the tests from which yield data were obtained and in 16 of theese there were significant differences in yield between the various treatments. In these 16 tests, the yield from the formaldehyde-treated seed was significantly inferior to that from the seed treated with Ceresan, in 11 cases, to that treated with copper carbonate, in 9 cases, as well as to the yield from the untreated seed, in 9 cases.

DISCUSSION

Although drought conditions were more or less general during the 4-year period covered by these tests, yields averaging more than 10 bushels per acre were obtained in approximately half of the tests from which yield data were secured. Consequently, it is believed that the general failure of the seed treatments to benefit either stand or yield cannot be attributed entirely to the occurrence of weather conditions unfavorable for flax production. European investigators (3, 6) have noted that seed treatment was most beneficial when seed of inferior quality was used, and in seasons when seedling-blight and damping-off (*Phythium* sp. and *Rhizoctonia* sp.) were prevalent. However, Burnett and Reddy (2) did not report any observation on these seedling diseases in tests in which they secured beneficial effects from the Ceresan dust treatment. The seed used in the tests reported in this paper was of good quality and no reports of seedling-blight or damping-off were received from any of the collaborators. Several of the collaborators noted a delay in germination and poorer stands in the plots sown with formaldehyde-treated seed, but no reports were received of any stimulatory effect of the Ceresan or copper carbonate treatments.

It should be pointed out that the only tests in which the stand from treated seed was significantly better than that from untreated seed were those conducted at St. Paul, Minn., in 1932 and 1933, and at Waseca, Minn., in 1932. These stations, as well as those in Iowa at which Burnett and Reddy (2) secured such beneficial effects from the Ceresan treatment, are in regions that have been under cultivation longer and have a more humid climate than those in which the other stations cooperating in these tests were located. The more humid conditions and the longer period that the soil has been under cultivation would tend towards an increase of the damping-off organisms in the soil. Although neither damping off nor seedling-blight were reported either in Minnesota or in the tests conducted by Burnett and Reddy in Iowa, it is possible that they escaped detection, as the plots were not under continuous observation. Flax is most susceptible to injury by the damping-off and seedling-blight organisms while very young, often failing to emerge, and when emergence of attacked plants does take place, the latter are often rapidly killed. The killed plants soon dry up and in a few days their detection is difficult.

It seems probable that seed disinfection would produce beneficial results in cases where the seed was contaminated with such seed-borne organisms as those causing canker or seedling-blight and browning. It is even possible that the residual effect of the fungicide on the seed coat might tend to delay the attack of the damping-off fungi. In regions where flax culture has been recently initiated and seed-borne diseases are not yet established, proper seed disinfection should aid in preventing or at least in delaying the establishment of these diseases. However, the tests reported in this paper indicate that little benefit can be expected from treating flax seed in North Dakota, South Dakota, Montana, and western Minnesota, and that under certain conditions the formaldehyde-spray treatment may be injurious.

SUMMARY

The results of cooperative flax seed-treatment tests at 11 stations in Minnesota, North Dakota, South Dakota, and Montana, are summarized.

The object of these tests was to determine the comparative effectiveness of the formaldehyde-spray and the Ceresan and copper carbonate dust treatments in controlling diseases and in increasing stand and yield of flax.

Flax diseases amenable to seed treatment, such as seedling-blight, browning, and damping-off, were of negligible importance during the four years covered by these tests and no accurate information was secured concerning the effectiveness of the different seed treatments in controlling these diseases.

None of the treatments had an appreciable effect on the incidence of wilt, in the wilt-susceptible variety, Damont, in 1 year's trials on either wilt-infested or non-infested farm soils.

None of the treatments had a consistently stimulatory effect on either stand or yield. There was some indication that, under certain conditions, Ceresan and copper carbonate dust treatments benefited the stand in the more humid region of southeastern Minnesota.

The formaldehyde-spray treatment was distinctly injurious under conditions that prevailed during the period of some of these tests. It caused significant reductions in stand in approximately three-fourths of the tests and in yield in approximately one-third of the tests in which such data were secured.

Treatment of flax seed does not appear to be justified at present in the seed-flax producing regions of North Dakota, South Dakota, Montana, or the western part of Minnesota.

LITERATURE CITED

1. BOLLEY, H. L. Seed disinfection and crop production, methods and types of machinery needed. N. Dak. Agr. Exp. Sta. Bul. 87. 1910.
2. BURNETT, L. C., and CHAS. S. REDDY. Seed-treatment and date-of-sowing experiments with six varieties of flax. Phytopath. **21**: 985–989. 1931.
3. EGLITS, H. (Flachskrankheiten und Versuche zur Leinsaatbeize in den Jahren 1929–1931.) Latvijas Augu Aizsardz. Inst. Raksti.) Acta Inst. Defens. Plant. Latv. **2**: 5–32. 1932. (German summary).
4. KLETSCHETOFF, A. N. (Methods for the control of flax sickness in soil.) (Flax and Hemp Indus. News.) Moscow. **7**: 488–500. 1930. (In Russian).
5. MEDISH, M. N., and J. S. RARO. (Experiments on flax-seed disinfection in 1929.) (Gorky Agr. Exp. Sta. Phytopath. Div. Bul. **44**: 23–30. 1930. (In Russian).
6. SCHILLING, E. Versuche über Beizung und Stimulation von Leinsaat. Faserforsch. **4**: 212–234. 1925.
7. ————. Zur frage der Trockenbeizung von Leinsaat. Faserforsch. **6**: 105–115. 1928.

THE INFLUENCE OF DRY AIR ON THE LONGEVITY OF THE FIRE-BLIGHT PATHOGEN[1]

H. R. Rosen

(Accepted for publication May 22, 1935)

It is commonly believed that the fire-blight pathogen, *Erwinia amylovora* (Burr.) Com. S. A. B. (*Bacillus amylovorus*) is very sensitive to dry air.

"The pear-blight microbe is a very delicate organism and cannot withstand drying for any length of time. In blighted twigs exposed to ordinary weather it dries out in a week or two and dies" (17).

"This germ forms no spores, is very sensitive to drying, and, in fact, is a very short-lived organism. It dies rapidly in the blighted tissues as soon as they have become fully killed by the germs. It cannot withstand drying, usually dying within two weeks to a month" (18).

"The process of killing (referring to the fire-blight pathogen) is often, although not always, simply that of desiccation" (3).

The fire-blight organism is "dry-air-sensitive" (p. 369) and is (p. 380) "killed quickly" by dry air (13).

"It has been demonstrated that the bacteria will live several weeks, or even months, in the blight-cankered limbs that have been cut away and left lying around. As these dry out, however, the bacteria die with the dying wood" (4).

"The more concentrated sugar solutions (such as are found in blossoms in dry weather) not only are unfavorable to the development of bacteria, but also weaken their virulence so that they are feeble or entirely impotent in the production of blight" (16).

Contrary to these citations and various others of similar nature, there are a few investigators who have found the fire-blight pathogen to be relatively long lived under dry conditions. Among these are Waters (19) who very briefly noted that in New Zealand the bacteria under consideration are "capable of living in dried exudate for a period of nine months." How "dry" the environmental conditions were, is not stated. Similarly, Thomas, as reported by Pierstorff (8), "obtained virulent organisms twelve months after infected limbs had been brought into his laboratory," and Pierstorff (8) obtained pure cultures of the organism for a period of 2¼ years from dried ooze on Transcendent crab-apple trees, kept in the laboratory.

So far as these empirical tests are concerned, and similar ones made by the writer, there is no clear understanding as to the actual "dryness" of the

[1] Research paper No. 396, Journal Series, University of Arkansas.

ooze or of the material from which the bacteria were cultured. Likewise, the common procedure of smearing pure cultures of bacteria on sterilized glass slides or cover slips that are allowed to remain "dry" under diverse laboratory conditions for varying lengths of time, gives neither a clear idea of the actual dryness involved nor of the possible behavior of the bacteria on natural hosts (9, p. 381). Aside from daily and seasonal fluctuations in air humidity in any one region, there is of course much difference to be expected in this respect in different parts of this country as well as in unlike countries, and what would be considered dry in one region might well be taken to be otherwise in another. Clearly, unless one knew the relative humidity or saturation deficit, or had some other measure of the dryness to which any given material is subjected, there can be no adequate means of duplicating comparable conditions or of drawing conclusions relative to the response of *Erwinia amylovora* to actual dry conditions.

EXPERIMENTAL DATA

For a comparison with results obtained in other sections of the country, it was considered desirable in preliminary experiments to attempt to duplicate in some measure the previous work. For this purpose, hardened bacterial droplets of exudate attached to blighted tissues and kept in ordinary paper packets in the laboratory for varying lengths of time, were on May 24, 1934, placed in small quantities of sterile water and allowed to form a noticeable cloudy suspension. Several hypodermic injections were made from each collection into tender Bartlett pear shoots maintained on potted plants in a greenhouse. Exudate from the following material was used:

1. Jonathan apple twig gathered April 15, 1927. 2. Bartlett pear twig gathered April 22, 1927. 3. Jonathan apple twig gathered April 29, 1927. 4. Jonathan apple twig gathered May 3, 1927. 5. Jonathan apple twig gathered May 8, 1933. 6. Jonathan apple twig gathered May 5, 1934.

It will be noted that in the first 4 of these, the exudate was about 7 years old; in the 5th one, slightly more than a year old; and the last, to serve as a check, not more than 19 days old. As a further check on the injections, a series of poured dilution plates with nutrient dextrose agar was used from one of the older samples of exudate (number 1). The droplets of hardened ooze varied in size from that of a mustard seed to that of a garden pea. The results were as follows: No infections were obtained and no bacterial colonies resembling *Erwinia amylovora* developed from the first 5 samples. All the shoots inoculated with Sample 6 produced typical blight symptoms within 4 days after the inoculations.

On June 6, 1934, the experiment was duplicated, except that Sample 1 was not represented. Likewise, a series of poured dilution plates was made from each sample. The results were similar to those previously ob-

tained. Only from Sample 6, representing exudate from the current year, were infections produced and colonies of *Erwinia amylovora* obtained.

One may conclude either that Thomas and Pierstorff's findings in New York are not applicable to Arkansas conditions with reference to the longevity of bacterial exudate kept under laboratory conditions, or that other factors than dryness may be involved. While it is not surprising to find material 7 years old failing to yield virulent cultures, it is obvious that the one-year-old material should have produced infections, if Thomas's and Pierstorff's findings are correct and widely applicable.

But as stated previously, the "dryness" of an Ithaca, New York, laboratory may not be comparable to that of one in Fayetteville, Arkansas. Consequently, a more exact experiment was designed to answer the question relative to the influence of dry air on fire-blight bacteria contained in hardened exudate. It consisted of, first, the use of concentrated sulphuric acid in a sealed, glass bottle with bacterial exudate suspended over the acid;[2] second, as a control, bacterial exudate gathered at the same time and on the same host placed in corked vials outdoors without acid; and third, as a further check, bacterial exudate was permitted to remain in place on a blighted pear tree.

The method used for placing the exudate over the sulphuric acid was essentially the same, with slight modifications, as that used by Noble (5). One modification consisted in using about 100 c.c. of c.p. acid, with a specific gravity of 1.835 without any water added, in a 200 c.c. large-mouth bottle, and suspending a paraffin-covered paper basket from the rubber stopper. The bottom of this open basket rested slightly less than one inch above the level of the acid. The exudate, gathered from blighted Jonathan apple and Bartlett pear shoots on May 5, 1934, and on June 11, 1934, was kept in the laboratory with the bases of the shoots immersed in water until June 12, 1934. On that date the exudate was removed from the diseased host tissues and divided into 2 lots. One lot was placed in the paper basket suspended over sulphuric acid, the bottle being tightly stoppered and sealed with melted paraffin, and the other lot was placed in small vials, corked but not sealed with paraffin, and hung in a wire basket suspended from a limb in an apple tree.

The exudate, which was permitted to remain in place on a blighted pear trunk, consisted of a thick copious flow that had occurred on the east side of the trunk from a canker of the current year's origin. It was first observed on June 23, and judging by the color and hardness of the ooze, it must have exuded approximately a week or 10 days previously. That it was

[2] The avidity of this acid for water has been made use of by previous investigators in attempting to get measurable degrees of relative humidity for determining the behavior of various species of fungi and bacteria under varying degrees of dryness (15, 6, 7, 5).

still in place and rather sharply delimited, indicated that it appeared after the heavy rain, wind, and hail storm of June 10. This date marked the beginning of a dry period that remained unbroken until the latter part of August. This extreme drought, shared by a large part of the country, enabled the gathering of portions of the pear exudate throughout the summer and formed a desirable check on the exudate suspended over the concentrated sulphuric acid. The portion of the trunk upon which this exudate appeared was fully exposed to the east sunlight.

The method of testing and the results of the tests made with these 3 different treatments of exudate are as follows: The exudate in each instance was placed in sterile water, the bacteria permitted to form a heavy suspension, and used both as direct injections into healthy succulent shoots of Bartlett pear in the greenhouse, and for poured dilution plates with nutrient dextrose agar as the medium. Samples from the exudate left in place on the blighted pear trunk were gathered on June 26 and on July 17 and tested for viability and infectivity. The results were wholly negative, no

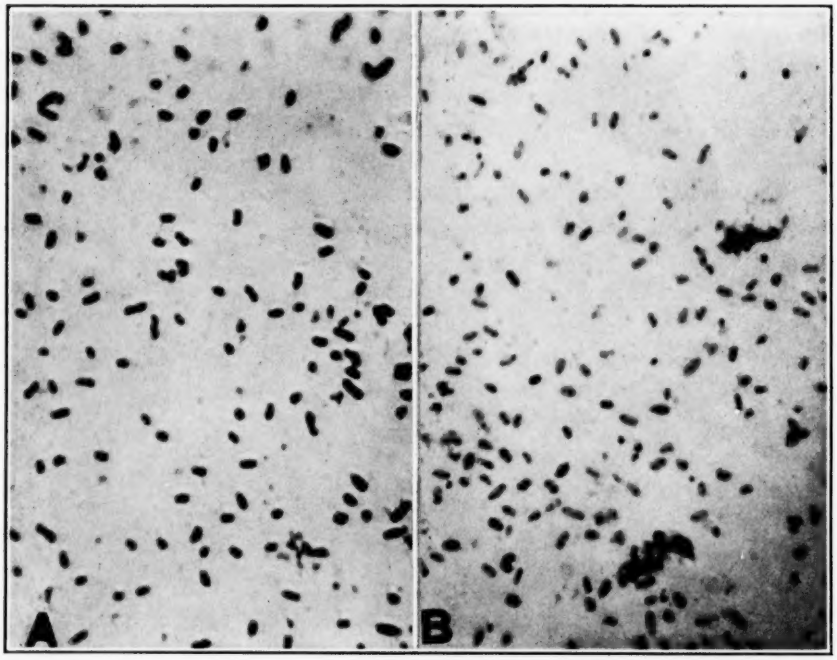


FIG. 1. Fire-blight bacteria contained in exudate (×1840). A. Kept at a relative humidity close to zero for a period of about 8 months. These bacteria were viable and virulent. B. Kept in closed, humid vials outdoors for about 8 months, when they were no longer viable. Note how faintly and unevenly the bacteria are stained with polar granules often in evidence.

colony appearing on the poured plates that resembled *Erwinia amylovora*, and no infections appeared from the direct injections with the diluted exudate.

Samples from the exudate placed in corked vials and suspended from an apple tree were gathered in September, November, and December and similarly tested. Here again the results were negative, and when a stained smear of the exudate made early in January, 1935, was compared with the still viable and infectious exudate kept over sulphuric acid, the bacteria were largely in the form of relatively minute ghost cells, often containing faintly stained polar granules (Fig. 1, B). It was noted that the vials contained free moisture, and that the exudate was covered with various molds within several weeks after they had been placed in the vials.

Samples from the exudate placed over concentrated sulphuric acid were tested on September 10 and November 12, 1934, and March 19, and May 7, 1935. The last date represented a full year after the first exudate had been gathered. In each instance viable and infectious bacteria, producing typical fire-blight symptoms, were obtained. The specific gravity of the sulphuric acid was tested on November 12, 1934, and again on May 7, 1935, and gave in both instances a reading of 1.8140, due allowance being made for temperature.

The fact that *Erwinia amylovora* in the form of exudate can live for a year at least (the tests are being continued) in a bone-dry atmosphere in which the relative humidity is close to zero,[3] constitutes a wholly unexpected phenomenon that is not at all in accord with prevailing belief concerning the influence of dryness on the longevity of fire-blight bacteria. Obviously, some other factors are involved in reducing the length of life of these bacteria when in the form of extruded ooze under some outdoor conditions or within various host tissues on the plant. The nature of these factors can merely be conjectured, but among those that must be considered are sunlight, other microorganisms, and the chemico-physical composition of the host materials in contact with the bacteria. Instead of dryness being the cause of short life, it may be that the reverse is true. The presence of various quantities of moisture would result not only in changes in the physical condition of the bacterial protoplasm and of the gelatinous matrix in which the bacteria are enveloped, but also in favoring the germination and growth of air- and water-borne competing microorganisms. The writer has already directed attention to a yellow bacterial saprophyte rather commonly associated with *Erw. amylovora* that has a marked inhibiting effect on the life of the fire-blight bacteria (10, p. 65).

[3] According to the physical tables (15, 20, 21), concentrated sulphuric acid with a specific gravity of 1.8140 yields a relative humidity of around zero.

Aside from the studies detailed above, 2 additional lines of investigation have been in progress during the past few years on the exudates of fire blight. While these were conducted with the primary purpose of determining the presence or absence of live bacteria on the surface of blighted and overwintered tissue and in the soil beneath badly blighted pear and apple trees, they have a direct bearing on the question under discussion. As previously reported (11, p. 50), in approximately 150 different attempts to isolate the pathogen from the surface of diseased twigs and limbs of both apple and pear, gathered throughout the winter and early spring of 1933–1934, all were negative. Only 2 positive isolations have been obtained, both in midwinter of 1932–33, one by soaking a blighted apple twig in sterile water for a few minutes, and the other by first coating the cut end of a blighted pear twig with paraffin and then soaking. In view of the very small number of successful isolations, it may be questioned whether bacterial exudate remaining on the exposed surfaces of twigs and limbs of pear or apple forms a common or important means of overwintering. In view of the findings here reported on the influence of dry air on fire-blight bacteria, this is to be expected, since dryness for any length of time during the fall and winter is seldom experienced in the fruit-growing section of Arkansas. On the other hand, in exceptional dry seasons or in dry shelters during moist seasons, and when other factors would not counterbalance the aridity, or in any region that normally has a very dry climate, it is conceivable, in view of the results here reported, that the bacteria would have a better chance of surviving for greater time intervals.

Much of the bacterial ooze extruded from pear and apple tissues must undoubtedly reach the soil beneath and around the trees, and also possibly be carried at times by strong winds when accompanied by rains into upper air currents and be deposited considerable distances from the place of origin. Ark (1) has found that in artificially contaminated sterilized soils the organism will live as long as 54 days at a temperature of 8° C., 30 days at 21°, and as long as 38 days in non-sterilized soil kept at 8° and at 21°. From soils naturally contaminated he obtained infections from samples gathered through the summer and up to November 18. Thomas and Ark (16) in additional studies found the bacteria viable in naturally contaminated orchard soil throughout the winter of 1932–33 up to March 31, but the number of successful isolations gradually diminished. They conclude, therefore, that their results suggest that the soil is probably unimportant in overwintering the bacteria.

During the fall and winter of 1934–35, the soil from beneath badly blighted pear and apple trees, from one orchard at Fayetteville and another near Rogers (Benton County), Arkansas, was investigated for the presence of infectious fire-blight bacteria. In each instance the sample was charted

with reference to location, the trowel flamed after each sample was gathered, and the soil placed in sterilized cardboard containers, weighed shortly after it was collected. Only the top 2 inches was utilized. The weights varied in the different samples from about 200 to 300 grams, the average being around 250 grams (moist weight). Each sample was placed in 100 c.c. of sterile water and a series of dilution plates made from each. The diluted soil mixture also was used for direct hypodermic injections into Bartlett pear shoots. The results are as follows: From 15 soil samples gathered near Rogers on December 19, 1934, none yielded *Erwinia amylovora*. Likewise, from 42 soil samples gathered at Fayetteville on January 14, February 16, and March 1, 3, and 9, 1935, no fire-blight bacteria were obtained.

These negative results, however, are not considered conclusive, for the reason that the technics now available for soil isolations of *Erwinia amylovora* are far from being certain. The writer has found that the crystal-violet-bile agar medium (1), which tends to eliminate gram-positive microorganisms, also has a more or less marked deleterious effect on the growth of the fire-blight pathogen. This effect, it was found, varied considerably and depended in large part on the batch of dye in use. Apparently, crystal violet has been insufficiently standardized to yield the same results at all times. The samples of this dye at hand, when used as Ark (1) recommended, in dilutions up to 1 to 100,000 on pure cultures of *Erw. amylovora,* and compared with similar quantities of inoculum on nutrient dextrose agar, inhibited approximately 75 per cent of the colonies. Furthermore, when a soil sample is diluted with water, and then inoculated into susceptible hosts, there is no assurance that infections will be obtained, even if *Erw. amylovora* is present. As will be reported elsewhere, the degree of bacterial dilution, other things being equal, has a very direct bearing on the initiation and development of blight.

Although one may properly question the reliability of the tests utilized on soil samples for determining the presence of *Erwinia amylovora,* the results cited previously concerning the influence of dry air on bacterial exudate, suggest that the longevity of the fire-blight pathogen in the soil would depend in part at least on the degree of dryness of the soil. In moist or wet soil, the bacteria, in accordance with these tests, would not live so long as in dry soil. Likewise, in dry soil, unless the bacteria become lodged in places that shield them from the direct rays of the sun, they would be markedly inhibited.

The results obtained with the exudate exposed to sunlight on a pear tree also suggest that, under such conditions, the bacteria die in short order, not because of the dryness but probably because of the germicidal action of the sun's rays. The effect of different temperatures in the presence of dry air

must also have its influence on the longevity of the bacteria, but this remains to be determined.

It is to be especially noted that the experiments detailed above were confined wholly to exudates extruded naturally from blighted host tissues. If pure cultures from artificial media were used, the results might be quite different. Peltier (6), who made a thorough painstaking study on the effect of temperature and humidity on the citrus-canker pathogen, *Phytomonas citri*, found that when pure cultures of the citrus-canker bacteria, grown in nutrient broth, were used for humidity and temperature studies, humidity had little or no influence at low temperatures, while at high temperatures, high humidities were the limiting factors. At medium humidities the organism was viable at all temperatures for the period of the experiment (8 days). Working with the same pathogen, Stevens (14) reported that it was viable and infectious when kept in dry sterilized soil for a period of 26 months.

THE INFLUENCE OF DRY AIR ON THE MORPHOLOGY OF THE ORGANISM

It has been suggested (8) that there may be resting forms of *Erwinia amylovora*, as cysts or involution forms "which may be more resistant to adverse conditions and may approximate in function and characteristics the endospores formed by such species as *Bacillus botulinus*."

To test this theory a microscopic study was made of stained and unstained preparations of bacterial smears from the viable exudate kept over sulphuric acid, as well as from the nonviable exudate kept in vials outdoors. The most decided differences noted in both the stained and unstained preparations was the relative minuteness in size and the relative emptiness of the nonviable bacteria. They appeared to be mostly empty shrunken shells, with granules appearing frequently near the poles. In contrast to these, the viable bacteria were individually one to several times as large as the nonviable ones, and stained evenly and heavily with carbol-fuchsin (Fig. 1, A). There was no suggestion whatever of involution forms or cysts or endospores. When the bacteria kept over sulphuric acid for approximately 12 months were compared in stained smears with the bacteria contained in fresh exudate, there was no appreciable differences noted in form, in size, or in staining reaction.

When the bacteria that had been suspended over sulphuric acid for 8 months were compared with those in corked vials, kept outdoors for a similar length of time, using the Gay and Clark (2) recommendation (Proca-Kayser stain) for the differentiation of living from dead bacteria by staining reactions, the living bacteria kept in the very dry air stained violet or violet red, while the dead ones contained in the vials appeared as clear red. This differentiation was not quite so clear as Gay and Clark have

found for other bacteria, in which living ones stain blue and the dead ones red by the method utilized.

DISCUSSION

While the results here presented leave no doubt that the fire-blight producer can withstand exceedingly arid conditions for relatively long periods under indoor conditions, it still remains to be shown that it will do likewise outdoors under natural conditions. So far as the indoor temperatures are concerned, the laboratory temperatures during the year in which the bacteria were confined in the sulphuric acid bottle varied from 35° C. in the extreme heat of the summer of 1934 to around 20° C. during the winter. Naturally, the fluctuations were not so sharp as occurred outdoors. Nevertheless, if any exudate happens to become lodged in rifts or bark cracks or in any other place in and around the orchard, which may prevent access of rain or of direct sunlight, it is quite conceivable that they would remain alive for a relatively long time.

It seems desirable to point out that the studies here reported are confined entirely to the viability and infectivity of the organism. It does not concern its growth and reproduction. While dry conditions are seemingly conducive to long life, this does not mean that such conditions are also conducive to infection and disease development. Indeed, Shaw (12) has shown quite conclusively that a high relative humidity is necessary for good growth of *Erwinia amylovora,* 99.9 per cent relative humidity yielding maximum growth and grading downward to almost no growth at 95 per cent. Likewise, within susceptible hosts there is a direct relation between increased fire-blight resistance and lowered relative humidity in the intercellular spaces; 97 per cent relative humidity in these spaces was associated with complete resistance to infection and 100 per cent with maximum susceptibility. Shaw's studies, coupled with those here reported, serve as an excellent illustration of an apparently common phenomenon of microscopic parasites, namely, conditions favorable for long life are often the reverse of those that favor growth and pathogenic expressions.

SUMMARY

In air-dry bacterial exudate attached to blighted twigs and exposed to laboratory air at Fayetteville, Arkansas, for varying periods of time, the bacteria were found to be dead at the end of a year.

When similar exudate is kept under the same conditions, but is otherwise confined in an atmosphere approaching a relative humidity of zero, the bacteria are still viable and infectious about a year after they have been confined to these extremely dry conditions.

Fire-blight exudate kept in corked vials suspended from an apple limb under outdoor conditions yielded no viable fire-blight bacteria within 3 months after the exudate was thus confined.

Exudate left in place on a cankered pear trunk and gathered at various intervals after it had extruded from the tissues, showed no viable pathogens within 3 weeks after its extrusion. This exudate was fully exposed to direct sunlight, but remained dry during the summer drought of 1934.

Tests made from 67 soil samples taken beneath badly blighted apple and pear trees during the winter months of 1934–35, from December to March, showed no viable *Erwinia amylovora* in any exudate that may have lodged in the soil. These tests, however, owing to the questionable technics now available for isolating the fire-blight pathogen from nonsterilized soil samples, are not considered conclusive evidence for absence of this parasite in the soil during the winter months. The experiments cited previously suggest that, under soil conditions, the longevity of the organism would depend in part on the degree of dryness of the soil, and this varies from year to year.

A morphological study of the viable bacteria kept under extremely dry conditions for about a year show no endospores, cysts, or involution forms. When compared with bacteria kept outdoors in closed vials, under conditions in which they have lost viability, the dry living bacteria are larger and stain more heavily and evenly than the dead ones. The Proca-Kayser method for the differentiation of living from dead bacteria by staining reactions stains the viable bacteria violet or violet-red and the dead ones clear red.

AGRICULTURAL EXPERIMENT STATION,
UNIVERSITY OF ARKANSAS,
FAYETTEVILLE, ARK.

LITERATURE CITED

1. ARK, P. A. Behavior of *Bacillus amylovorus* in soil. Phytopath. **22**: 657–660. 1932.
2. GAY, F. P., and A. R. CLARK. The differentiation of living from dead bacteria by staining reactions. Jour. Bact. **27**: 175–189. 1934.
3. HOTSON, J. W. The longevity of *Bacillus amylovorus* under field conditions. Phytopath. **6**: 400–408. 1916.
4. JONES, D. H. Fire blight and its eradication. Ontario Dept. Agr. Bul. 342. 1929.
5. NOBLE, R. J. Note on the longevity of spores of the fungus *Urocystis tritici* Koern. Jour. & Proc. Royal Soc. New South Wales **67**: 403–410. 1934.
6. PELTIER, G. L. Influence of temperature and humidity on the growth of *Pseudomonas citri* and its host plants and on infection and development of the disease. Jour. Agr. Res. **20**: 447–506. 1920.
7. ———. A study of the environmental conditions influencing the development of stem rust in the absence of an alternate host. I. The viability of the

urediniospores of *Puccinia graminis tritici* form III. Nebr. Agr. Expt. Sta. Res. Bul. 22. 1922.

8. PIERSTORFF, A. L. Studies on the fire-blight organism, *Bacillus amylovorus*. New York (Cornell) Agr. Expt. Sta. Memoir 136. 1931.
9. ROSEN, H. R. A bacterial disease of foxtail (*Chaetachloa lutescens*). Ann. Missouri Bot. Gard. **9**: 333–402. 1922.
10. ————. The relationship of different species of pomaceous hosts to overwintering of the fire-blight germ. Ark. Agr. Expt. Sta. Rept. **41** (Bul. 246): 64–66. 1929.
11. ————. Fire blight of apples and pears. Ark. Agr. Expt. Sta. Rept. **46** (Bul. 312). 1934.
12. SHAW, L. Intercellular humidity in relation to fire-blight susceptibility in apple and pear. New York (Cornell) Agr. Expt. Sta. Mem. 181. 1935.
13. SMITH, E. F. An introduction to bacterial diseases of plants. 688 pp. W. B. Saunders Co., Philadelphia. 1920.
14. STEVENS, H. E. Report of Plant Pathologist. Fla. Agr. Expt. Sta. Rept. **1916–1917**: 66–75. 1918.
15. STEVENS, N. E. A method for studying the humidity relations of fungi in culture. Phytopath: **6**: 428–432. 1916.
16. THOMAS, H. EARL, and P. A. ARK. Fire blight of pears and related plants. Calif. Agr. Expt. Sta. Bul. 586. 1934.
17. WAITE, M. B. The cause and prevention of pear blight. Yearbook U. S. Dept. Agr. **1895**: 295–300. 1896.
18. ————. Pear blight work and its control in California. Thirty-first Fruit Growers' Convention of the State of California, 1905: 137–155. 1906.
19. WATERS, R. Fireblight. Incidence of the disease in New Zealand. New Zealand Jour. Agr. **24**: 350–357. 1922.
20. WILSON, R. E. Humidity control by means of sulphuric acid solutions with critical compilation of vapor pressure data. Jour. Ind. Eng. Chem. **13**: 326–331. 1921.
21. ————, and T. FUWA. Humidity equilibria of various common substances. Jour. Ind. Eng. Chem. **14**: 913–918. 1922.

SPREADER MATERIALS FOR INSOLUBLE COPPER SPRAYS

H. C. Young and J. R. Beckenbach

(Accepted for publication May 23, 1935)

Many and varying types of spreaders[1] are being used with spray materials. They are placed there because of their effect on spreading, sticking, and fluffing; as diluents, absorbing agents, and stabilizers; and for protection to plants and, perhaps, for many other purposes. In many cases a spreader material may be satisfactory in one way and of little use as a general corrective agent. There are many spray materials that require reinforcement only in spreading or adhesiveness; there are other materials requiring a diluent, such as many of the dust mixtures; and there are others that are active as fungicides or insecticides when they are in a soluble form or in the gaseous state. Such materials, to be effective and lasting, must necessarily be adsorbed by a spreader that has most of the above qualifications.

No attempt will be made here to review the literature dealing with spreader materials. The greater part of the investigations on this subject has been done by concerns manufacturing spray materials who have either kept their results secret or have patented their combinations. In addition, many proprietary spreaders have appeared on the market. As a result of the writers' attempt to review the literature it was found that this or that material had been used, but rarely were comparisons made or fundamental reasons given for its particular use. The problem of spreaders for spray materials is complicated and too little fundamental research has been done on it.

This investigation has had to do primarily with the clay type of spreaders. For the past several years considerable experimental work has been done on a number of insoluble copper compounds. These coppers have been developed as substitutes for Bordeaux mixture in an attempt to reduce copper injury. Their effectiveness as fungicides has been somewhat disappointing, and preliminary tests indicated that a part of this ineffectiveness was due to their lack of adhesiveness. An attempt, therefore, was made to add a spreader material in a ratio that would correct this defect. Since it was necessary, too, to select a material that was chemically inactive, the safest group seemed to be the clays.

The method used in this work was the thorough mixing of the insoluble copper with the spreader material and then the atomizing of the mixture onto glass slides. In preliminary tests it was found that paraffining, shellacking, or painting the slides did not add to the adhesiveness. It also was

[1] Used as a general term.

found that clean glass slides were very comparable to foliage. The various combinations were mixed in a mortar and made up to the correct proportions, the formula used being comparable to those generally followed in making up sprays. The mixtures were then atomized onto thoroughly cleaned glass slides with a No. 15 DeVilbiss atomizer. The slides were 3¼ by 4 inches; the atomizer was held 22 inches from the slide, and 16 full squirts in rapid succession were applied to each slide. This gave a complete coverage of fine drops and was very comparable to sprayed leaves. Each slide was allowed to dry and then was dipped 10 times in 80 c.c. of distilled water. Each dip included the complete immersing of a slide, raising it from the container, draining it, and giving it a sharp jerk so that the large drops of water fell into the beaker. The alternate dipping and draining were of approximately 1 second duration each. The wash water was then transferred to a 100 c.c. volumetric flask and made up to 100 c.c. with 1:2 hydrochloric acid.

The residue on the slides was removed with 75 c.c. of 1:5 hydrochloric acid made up to 100 c.c. The sodium diethyl dithiocarbamate colorimetric quantitative method of Williams[2] was used with necessary modifications.

The necessary aliquot, containing the amount of copper within reading range of the standard solution[3] was placed in a small separation funnel and 10 c.c. of 1 per cent sodium diethyl dithiocarbamate solution added.

Color was extracted with 10 c.c. of chloroform by shaking vigorously in the separation funnel. This was then compared with the standard in the colorimeter, the reading noted, and computations made.[4]

The spreader materials, copper compounds, formulae and results are given in table 1. The results are averages of duplicates.

The results indicate that basic copper sulphate, basic copper chloride, and copper phosphate, when used without a sticker, adhere to slides very poorly. Of the clays used, bentonite and a specially treated bentonite called Wyojel were effective. These 2 bentonites also varied in their effect on sticking when larger percentages were used.

In order to determine the effect of the quantity of bentonite and Wyojel on sticking a second series was arranged. The amount of copper was held constant in the formula and the amounts of the 2 clays were varied from

[2] Williams, W. The determination of copper and iron in dairy products. Jour. Dairy Research 3: 93–100. 1931.

[3] The copper standard contains .02 mg. copper, using C.P. $CuSO_4$. Computations made on copper content. The standard is made up by taking an aliquot containing .02 mg. copper, adding 10 c.c. of .1% carbamate solution, a few drops of HCl, and extracting the color with 10 c.c. chloroform.

[4] Computations from colorimeter reading. Sample determination.

$$\frac{25\ (\text{Set reading of standard on colorimeter})}{24.2\ (\text{Reading of unknown})} \times .02\ (\text{mg. copper in standard}) = \frac{25}{24.2} \times .02 = .02066\ \text{mg. of copper in unknown.}$$

TABLE 1.—*Copper residues of basic copper sulphate, basic copper chloride, and copper phosphate on slides after washing*

Spreader material	Per cent copper residue 2–2–50 formula[b]			Per cent copper residue 2–10–50 formula[b]		
	Basic copper sulphate	Basic copper chloride	Copper phosphate	Basic copper sulphate	Basic copper chloride	Copper phosphate
Check—no spreader	33.8	27.2	22.6	.....	.....	.....
Bentonite[a]	95.5	89.6	92.7	59.6	26.6	32.0
Wyojel	95.0	92.3	90.5	85.4	96.4	54.7
Talc	38.8	.....	.....	62.3	.....	.....
Bancroft clay	41.6	.....	.....	74.0	.....	.....
Flour	60.6	.....	.....	.....	.....	.....
Bordeaux, 4–6–50	97.0	.....	.....	.....	.....	.....

[a] Wyobond bentonite was used in all of these tests.

[b] Pounds in gallons of water.

0.1 pound to 10 pounds. The formulae and results are given in table 2 and are shown graphically in figure 1.

The physical difference between the bentonites and the other clays, such as kaolin, talc, and Bancroft, was in the flocculation. This is shown in figure 2.

The bentonite and Wyojel flocculated about the same as Bordeaux mixture, but settled slightly more rapidly. The other clays did not flocculate, and they settled out with the copper in a very few minutes. It was first thought that there was a definite correlation between flocculation and sticking, since the effect of the bentonites was much greater than in the case of

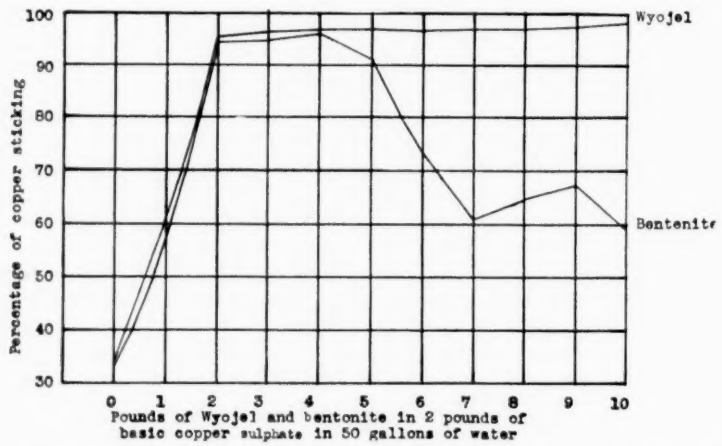
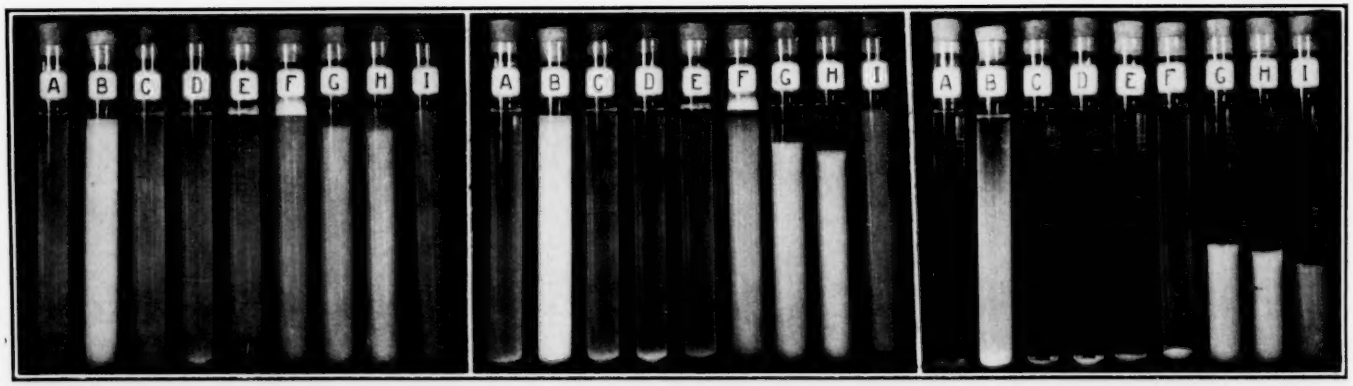


FIG. 1. Comparative effect of Wyojel and bentonite on adhesiveness of basic copper sulphate.



After 10 minutes | After 30 minutes | After 12 hours

FIG. 2. Flocculation after indicated period. A. Check (no spreader); B. Tale; C. Baneroft; D. Kaolin; E. Flour; F. Fluxit; G. Wyojel; H. Bentonite, and I. Bordeaux.

TABLE 2.—*Copper residues. Comparisons of Wyojel and bentonite with basic copper sulphate*

Formula	Percentage residue sticking	
	Wyojel	Bentonite
2– .1–50	37.2	43.5
2– .2–50	43.5	47.0
2– 1–50	59.6	56.0
2– 2–50	94.96	95.5
2– 3–50	96.18	95.2
2– 4–50	96.7	96.3
2– 5–50	96.7	91.5
2– 6–50	96.2	73.1
2– 7–50	96.8	60.1
2– 8–50	96.4	64.8
2– 9–50	97.2	67.7
2–10–50	98.1	59.6
Check—no spreader	33.8	.....

the other clays. However, when greater quantities of bentonite were added, flocculation and jelling increased and adhesiveness decreased. On the other hand, Wyojel remained effective in all concentrations used.

Comparison of Bentonite and Wyojel with Coposil and Cuprocide

This test was set up in exactly the same way as the preceding ones. The formulae and results are given in table 3.

TABLE 3.—*Copper residue. Comparison of bentonite and Wyojel with Coposil and Cuprocide*

Spreader material	Residue			
	Coposil		Cuprocide	
	2–2–50	2–10–50	2–2–50	2–10–50
	Per cent	*Per cent*	*Per cent*	*Per cent*
Check	8.2	.....	83.3	.....
Bentonite	82.4	81.6	93.8	54.2
Wyojel	91.6	84.6	93.0	89.4

The results recorded in table 3 indicate that Cuprocide sticks very well alone. However, the copper content is high in this compound and for general use, particularly in dusts, diluents are necessary. Hence, it would seem that Wyojel would be far superior to the bentonite.

The 2–10–50 formula is comparable to the one advised by Wilson[5] for cucurbit spraying or dusting; that is, 1 pound of insoluble copper, 5 pounds of diluent, and 1 pound of arsenical may be placed in either 50 gallons of water or dusted directly on the plants.

DISCUSSION

The selection of a spreader material for a particular spray is not an easy task. There is not enough fundamental information to enable spreaders to be classified as to their uses. When a fluffer or diluent is needed, such materials as kaolin, talc, Bancroft clay, gypsum, or hydrated lime are more frequently used. Most of them will serve as diluents but the other necessary qualities may be lacking. Lime is a good diluent but frequently reacts chemically with the fungicide or insecticide rendering it less efficient. Basic copper chloride and hydrated lime are less effective on potatoes for the control of early blight than the copper chloride alone.

There is also the large group of organic spreaders, many of which are extremely effective as stickers. However, they are also apt to be chemically active and change the effect of the spray, in some cases rendering it unsafe to foliage. Just because a spreader is effective in one material does not warrant its general use without preliminary trial.

When all spreaders are considered, the bentonites are perhaps the most widely used. They are practically inert chemically, adhere well to foliage, and are good adsorbers. Their jelling property causes a type of flocculation such as occurs in Bordeaux mixture, which gives excellent spreading and sticking. Their adsorbing property makes them useful when mixed with soluble or gas forms of fungicides or insecticides, such as zinc sulphate, pyrethrum, cryolites or fluorides, nicotine, etc.

The use of bentonite is further complicated by the variation within the group. There are many types of bentonites. Three types were studied in this work, one of which reacted much like kaolin or talc, had little jelling property in dilutions, and did not adhere well. The Wyoming bentonite (trade name Wyobond used here) gave excellent results. The Wyojel, a patented product, is simply Wyoming bentonite with a low percentage of magnesium oxide. This is added to increase jelling and adsorption.

DEPT. OF BOTANY AND PLANT PATHOLOGY,
OHIO AGRICULTURAL EXPERIMENT STATION,
WOOSTER, OHIO.

[5] Wilson, J. D. New treatments for cucumbers. Ohio Agr. Expt. Sta. Bimo. Bul. 20(173): 68–75. 1935.

ON THE CLASSIFICATION OF PLANT VIRUSES

JORGEN M. BIRKELAND

(Accepted for publication July 10, 1935)

Johnson and Hoggan (6) have recently published a descriptive key for plant viruses that serves not only as a basis for classification but also calls attention to certain features of viruses most useful for diagnostic purposes. These features are:

1. Mode of transmission; 2. Natural or differential hosts; 3. Longevity *in vitro*; 4. Thermal death point; 5. Certain distinctive or specific symptoms.

Recent work on serologic tests and on induced plant immunity suggests that these reactions also may be of value in grouping viruses. The present chaotic state of nomenclature is due not so much to a lack of means of differentiation as to a lack of a suitable method for grouping viruses.

The serologic method, which has proved useful in identification of bacteria and in the discovery of their hidden relationships, has been applied to the study of a few plant viruses. It has been demonstrated that these agents are antigenic, that is, that they are capable of stimulating the production of precipitating, complement-fixing, and neutralizing antibodies when injected into rabbits. Furthermore, the antibodies are specific for a given virus (1), (2), (3), (5). Precipitin reactions and serum neutralization tests indicate (a) that the viruses studied fall into several distinct groups, and (b) that strains of the same virus are indistinguishable. Consequently, these tests are of particular value in grouping viruses. The relationship between strains of viruses is not always evident from a study of symptoms produced in the various hosts, since it has been shown that mutants or variants can be isolated that stimulate the production of symptoms quite different from those induced by the parent strain.

Mutation appears to be a common occurrence in certain plant viruses. By growing infected plants at high temperatures or by selecting portions from infected leaves showing different intensities of color, strains that "breed true" can be isolated. These strains, if encountered in nature, would undoubtedly be considered new viruses and would be named according to the symptoms produced on the hosts in which they are found. The pin-puncture and the leaf-excision methods used in isolating strains and the mechanical transfer of inoculum to healthy plants are more or less comparable to insect transmission. It seems probable, therefore, that insects in the course of their feeding serve as disseminating agents of variant viruses. This being true, we can expect a multiplicity of variants recognizable at first by different symptoms, but essentially the same by reason of

origin. To prevent confusion, the development of methods showing natural relationships is indicated.

The recent work of Thung (9), Salamon (8), Kunkel (7), and Caldwell (4) on immunity of plants from superinfection has shown that plants infected with certain viruses are immune from supposedly closely related strains but not from viruses that, according to certain criteria, are presumably unrelated. Caldwell has called attention to 4 types of response manifested by virus-infected plants when reinoculated with a second virus. They are:

"a. A virus may completely inhibit the development of another in the host tissues.

TABLE 1.—*A comparison of induced immunity reactions in plants with precipitin reactions of several plant viruses*

Virus used: (a) as serologic test antigen, and (b) to immunize plant	Virus used: (a) to produce antisera, and (b) to test plant for immunity	Reactions:	
		(a) Precipitin	(b) Plant
Tobacco mosaic	Aucuba (yellow)	+[a]	Protection
Tobacco mosaic	Aucuba (green)	+	Protection
Tobacco mosaic, attenuated	Tobacco mosaic	+	Protection
Tobacco mosaic, attenuated	Aucuba (yellow)	+	Protection
Valleau's ring mosaic	Aucuba (yellow)	+[b]	Partial protection
Tomato streak	Aucuba (yellow)	+[b]	Partial protection
Spotted wilt	Aucuba (yellow)	no data	No protection
Tobacco ring spot	Aucuba (yellow)	–	No protection
Cucumber mosaic	Aucuba (yellow)	–	No protection
Healthy potato (Johnson)	Aucuba (yellow)	–	No protection but production of new symptom complex (streak)
Healthy potato (Johnson)	Tobacco mosaic	–	No protection but production of new symptom complex (streak)

[a] Indicates a positive precipitin reaction. – Indicates no precipitin reaction.

[b] Reciprocal precipitin tests were not run, so it is not possible to state whether these viruses are serologically identical. The results obtained indicate however that they do show a relationship.

b. The second virus may multiply in the tissue without inducing typical symptoms.
c. The two viruses may multiply and induce symptoms, each inducing the typical symptom of its specific disease.
d. The effect of the second virus may be to cause a more severe disease than either could of itself have caused."

A good example of the last interaction (d) is "experimental" streak.

The parallelism between the serologic reactions of plant viruses and the reactions of induced or acquired immunity from those viruses in plants is striking. The following table is prepared from my own data on the precipitin tests and from papers by Caldwell (4) and Kunkel (7) on virus interactions. Viruses that induce a complete cross immunity in plants are serologically indistinguishable by the precipitin reaction; viruses that induce a partial cross immunity show serologic relationship; and viruses that do not induce cross immunity in a plant are serologically unrelated.

While these data are limited to a few viruses, their classification suggests the possibility of using such data in drawing conclusions relative to natural relationships of viruses.

DEPARTMENTS OF HYGIENE AND
BACTERIOLOGY AND BOTANY,
UNIVERSITY OF CHICAGO,
CHICAGO, ILLINOIS.

LITERATURE CITED

1. BEALE, H. P. Specificity of the precipitin reaction in tobacco mosaic disease. Jour. Expt. Med. 54: 463–473. 1931.
2. ————. The serum reactions as an aid in the study of filterable viruses of plants. Boyce Thompson Inst. Plant Res. 6: 407–435. 1934.
3. BIRKELAND, J. M. Serological studies of plant viruses. Bot. Gaz. 95: 419–436. 1934.
4. CALDWELL, J. On the interactions of two strains of a plant virus; experiments on induced immunity in plants. Roy. Soc. [London], Proc. Ser. B. 117: 120–139. 1935.
5. CHESTER, K. Specific quantitative neutralization of the viruses of tobacco mosaic, tobacco ring spot, and cucumber mosaic by immune sera. Phytopath. 24: 1180–1202. 1934.
6. JOHNSON, J., and I. HOGGAN. A descriptive key for plant viruses. Phytopath. 25: 328–343. 1935.
7. KUNKEL, L. O. Studies on acquired immunity with tobacco and aucuba mosaics. Phytopath. 24: 437–466. 1934.
8. SALAMON, R. N. Protective inoculation against a plant virus. Nature [London] 131: 468. 1933.
9. THUNG, T. H. Smetstof en plantengen bij enkele virusziekten van de tabaksplant. Nederland.-Indische Natuurw. Cong. 6, 1931. Handel. p. 450–463. [1931?]

INDEX TO THE RELATIVE SUSCEPTIBILITY OF ORCHARD APPLES TO CEDAR-APPLE RUST

IVAN H. CROWELL

(Accepted for publication June 20, 1935)

It is common observation by horticulturists and pathologists that the varieties of orchard apples differ in their susceptibility to the cedar-apple rust, and numerous varieties of apples have been reported as falling within certain groups or degrees of susceptibility. Two main methods have formerly been used to measure these degrees of susceptibility. Most prior investigators determined the relative susceptibility by a comparison of the number of lesions from visual observation. More recently Bliss[1] and Miller[2] gave accounts of statistical methods for determining relative susceptibility of orchard apples to cedar-apple rust. Their methods were based upon a count of the number of lesions on leaves of orchard apples.

It is common knowledge that the number of lesions varies in different years as well as in different orchards in the same year. It follows, therefore, that the results of such comparative and statistical methods of determining relative susceptibility also vary. Thus many varieties were reported by early investigators as belonging to 2 or more of the generally accepted grades or degrees of relative susceptibility, namely, immune, slightly, moderately, and very susceptible.[3] Similarly, in the accounts of Bliss[1] and Miller[2] the statistical results varied for the same variety of apple. In fact, in Bliss's account the results of 3 different years varied greatly and were not in most cases consistent. Which values, therefore, are to be accepted as the measure of relative susceptibility?

In an account of this rust by Crowell,[4] it was shown that the average number of aecia per lesion was directly related to the number of lesions on leaves of ornamental apples. Over a period of 4 years the number of aecia per lesion remained essentially constant, although in each of these years the

[1] Bliss, D. E. The pathogenicity and seasonal development of Gymnosporangium in Iowa. Iowa Agr. Expt. Sta. Res. Bul. **166**: 340–392.

[2] Miller, P. R. A method of estimating the percentage of infection of apple leaves by rust with observations on the relative susceptibility of species and varieties of Malus and Juniperus. U. S. Dept. Agr., Bur. Plant Indus., Plant Dis. Rpt. **18**: 159–163. (Mimeog.) 1934.

[3] Crowell, I. H. The hosts, life history and control of the cedar-apple rust fungus *Gymnosporangium Juniperi-virginianae* Schw. Jour. Arnold Arboretum **15**: 163–232. 1934.

[4] Crowell, I. H. A compilation of reports on the relative susceptibility of orchard varieties of apples to the cedar-apple rust disease. Amer. Soc. Hort. Sci. Proc. **32**: 1934. 261–272. 1935.

number per leaf[5] varied widely. To test this principle on orchard apples, infected leaves of several varieties collected at various times from various States were examined. It was found that the average number of aecia per lesion for each variety was remarkably constant. The average number was taken directly as the measure of relative susceptibility. To illustrate: The Wealthy, one of the most susceptible varieties, averaged 22 aecia per lesion and its relative susceptibility was designated by this number. In obtaining data, lesions whose individuality were obscured by their proximity to the edge of the leaf, to larger veins, or other lesions, were not used.

This method of measuring relative susceptibility of apples to cedar-apple rust is free from the effects of seasonal and geographical variations in the amount of infection. It is based upon the physiological reaction between the host and the parasite. It was shown in the investigations on ornamental apples that the fungus developed most abundantly on the more susceptible hosts and less abundantly on the more resistant ones. This phenomenon has been repeatedly observed on orchard apples. Thus the relative susceptibility of any variety of apple may be determined from few lesions and is independent of the abundance of infections. The results of this method, however, are subject to minor variations due to variations in the health of the tree, the time of infection, and certain other environmental variables. A major variable may result from the presence of local or physiologic strains of the rust organism, but our present knowledge of strains of this rust goes little beyond the fact of their existence. It is to be expected that a small amount of variation in the number of aecia per lesion will be found. This variation may be minimized, however, by grouping, and the establishment of limits for each group. The generally accepted group classification and the limits now set for each of these groups for orchard apples are as follows:

Immune—No evident infection spots. *Slightly susceptible*—One to 5 aecia per lesion. *Moderately susceptible*—Six to 15 aecia per lesion. *Very susceptible*—Sixteen or more aecia per lesion.

These limits in the number of aecia per lesion are reduced from that originally proposed for the grouping of ornamental apples. The reduction is due to the circumstance that none of the orchard apples are so susceptible as the most susceptible ornamental apples.

To this series of groups another member may be added to embrace those hosts on which infection results solely in the development of spermogonia. Such infections have been vaguely interpreted as flecks, spots, specks, yellow areas, etc. These hosts are very resistant to infection. Scientifically they are susceptible, while, practically speaking, they may be considered as im-

[5] *A Correction:* In my former article (1934) table V, p. 179, under heading *Number of cushions per leaf*, the 5.2 and 9.1 should be interchanged and under the heading *No. of aecia per leaf*, 375.2 should be replaced by 691.6, and 106.5 by 60.8.

mune, for, since they produce no aecia, they cannot reproduce the rust. This group may be known as the *spermogonial-host group* and should be placed between the immune and slightly susceptible groups.

This means of measuring relative susceptibility, based upon the physiological reaction between host and parasite, makes possible a classification of apples on a uniform basis, regardless of the number of lesions. Herbarium material as well as fresh specimens may be used. The results of infection in different years as well as from different localities may be directly compared and an accurate measure of relative susceptibility of orchard apples thus obtained.

PHYTOPATHOLOGICAL NOTE

Sclerospora graminicola on Millet in Minnesota.—During the summer of 1935 the writer made numerous observations and experiments to elucidate certain problems in connection with the development of *Sclerospora graminicola.* The results confirm some of the conclusions expressed by Hiura in his recent paper,[1] at that time unknown to the writer, and are summarized briefly in this note.

Sclerospora graminicola (Sacc.) Schroet. was abundant during 1935 on millet (*Setaria italica* (L.) Beauv.) and foxtail grass (*S. viridis* (L.) Beauv.) in the plots at University Farm, Saint Paul, Minnesota, and at the Coon Creek Experiment Station near Anoka, Minnesota. Primary and secondary symptoms of downy mildew, similar to those described by Weston,[2] were evident in both localities, but the primary were more common than the secondary. Yellow-green streaks running the entire length of the leaf of the dwarfed plant characterize the systemic primary infection, while the secondary infection consists of chlorotic local lesions (Fig. 1).

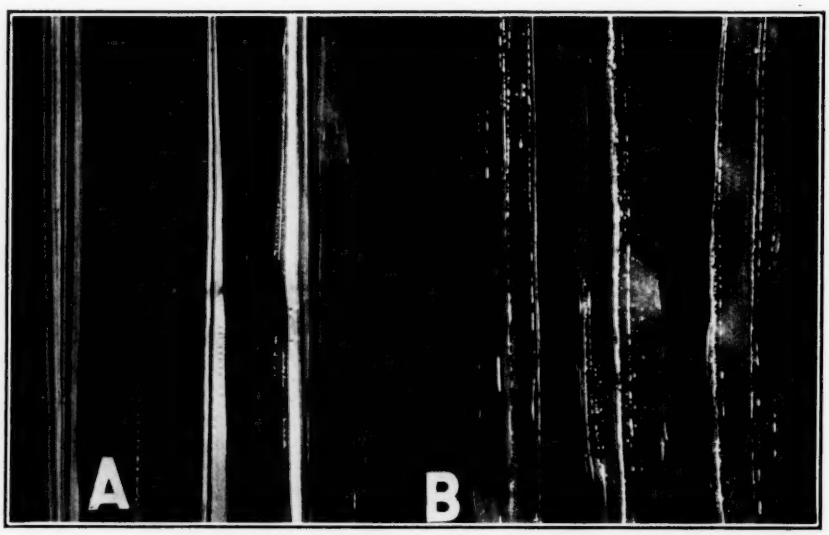


FIG. 1. A. Primary symptoms of *Sclerospora graminicola* on the fourth, fifth, and sixth leaves of an Italian millet plant. B. Secondary symptoms of *Sclerospora graminicola* on the fifth, sixth, and seventh leaves of an Italian millet plant. × ½.

[1] Hiura, M. Mycological and pathological studies on the downy mildew of Italian millet. Hokkaido Imp. Univ. Facult. Agr. Jour. **36**: 121–283. 1935.

[2] Weston, W. H., Jr., and G. F. Weber. Downy mildew (*Sclerospora graminicola*) on Everglade millet in Florida. Jour. Agr. Research **36**: 935–963. 1928.

Formation of conidiophores and conidia was observed in the millet plots at University Farm from July 15 to July 18, inclusive. Plants were examined at intervals throughout the day and night, and conidiophores and conidia were abundant on the lower leaf surfaces at all times and on the uppermost leaves of the plants, as well as on the lower. In order to determine the length of time required and the conditions necessary for spore formation, the old conidiophores were removed from the leaf blades with a cotton pad. A fresh crop of conidiophores grew through the stomata of the leaf within 4 to 6 hours, and conidia were formed 2 to 4 hours later (Fig. 2), the entire process requiring from 8 to 12 hours. A shorter time

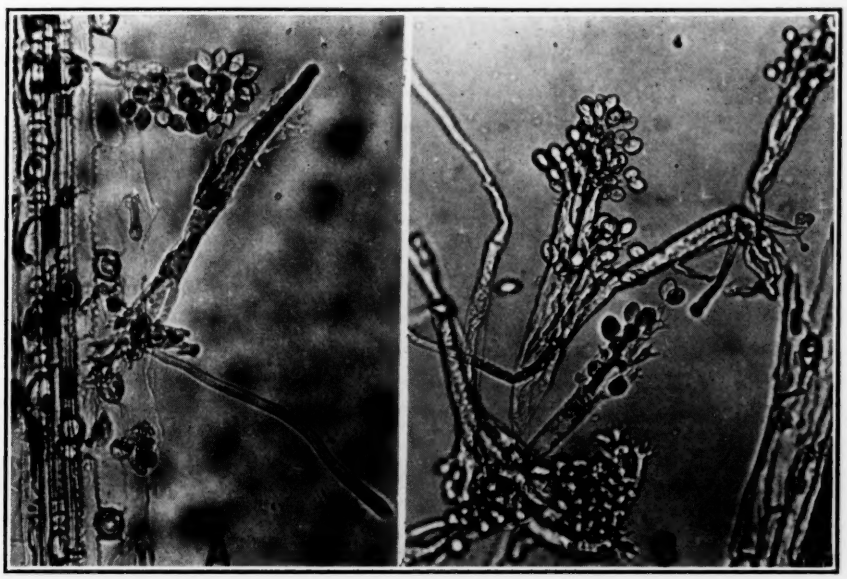


FIG. 2. A. Epidermis taken from the under surface of a diseased millet leaf at 10 a. m. showing young conidiophores growing out through a stoma, the remains of an old conidiophore, and a clump of conidia. B. Photomicrograph of conidiophores bearing conidia on short sterigmata. ×190.

(6 to 9 hours) was required when the material was placed in a moist chamber in the laboratory. During the four days of field observations the writer found that conidia were formed during the day, as well as during the night,[3]

[3] Weston reported that conidia were formed only during the night, but Melhus and his coworkers found them formed both day and night. See Weston, W. H., Jr., Nocturnal production of conidia by *Sclerospora graminicola*, Jour. Agr. Research [U. S.] 27: 771–784, 1924, and Melhus, I. E., F. H. Van Haltern, and D. E. Bliss, A study of *Sclerospora graminicola* (Sacc.) Schroet. on *Setaria viridis* (L.) Beauv. and *Zea mays* L., Iowa Agr. Expt. Sta. Research Bull. 111. 1928.

when temperature ranged between 17° and 34° C., and when relative humidity was between 75 and 100 per cent. Laboratory observations confirmed these field observations that agree in nearly all respects with the extensive report by Hiura.

One hundred conidiophores and conidia from *Setaria italica* were measured on July 17. The former were 182 μ to 251 μ long, with an average of 228 μ. The conidia averaged 21.4 μ × 14.2 μ, while the 50 giant conidia measured were 43.0 μ × 26.4 μ. The measurements of the fungus from *S. viridis* were slightly different, conidiophores averaging 184.4 μ in length, the ordinary conidia 19.2 μ × 14.7 μ, and the giant conidia 40.0 μ × 21.7 μ. Environmental factors are known to influence the size and shape of the conidia and conidiophores.

Mature conidia were washed from the leaf blades with sterile water. After 40 to 50 minutes in hanging-drop preparations or in Petri dishes at room temperature (23 to 30° C.) each conidium usually liberated about 4 zoospores. Some of them were killed and stained as in the method described by Cotner.[4] The biciliate condition is typically found in the species. The biciliate zoospores remained active for approximately 30 minutes, then withdrew their cilia and encysted as globular resting bodies. Later, a germ tube was formed, and an appressorium usually occurred at its tip. The germ tubes died after 3 or 4 hours if there was no proper host for infection.—C. S. WANG, University Farm, St. Paul, Minnesota.

[4] Cotner, F. B. The development of the zöospores in the Oömycetes at optimum temperatures and the cytology of their active stages. Amer. Jour. Bot. 17: 511–546. 1930.

PLANT QUARANTINE LEGISLATION—A REVIEW AND A REFORM[1]

H. T. Güssow[2]

INTRODUCTION

The serious economic losses resulting from the introduction of plant diseases or insect pests into the divers countries of the globe are so well known to plant pathologists and students of this subject, that no elaboration is required on this occasion. These often very costly and destructive invasions of a country's vegetal resources have given just cause for alarm. Let me briefly refer to the astoundingly large sums of money that have been spent on the Continent of America—notably by the United States—on two or three introduced diseases and pests since the days of their original introduction.

White Pine Blister Rust, *Cronartium ribicola* (*Peridermium strobi*), has involved expenditures in scouting and control of some $14,000,000; the advent of the Gipsy moth, an expenditure of some $41,000,000; while the European Elm disease, of comparatively recent introduction, has already caused an outlay of over $1,000,000, which is likely to materially increase, if extermination is contemplated. Indeed, during the past decade or so, the Continent of North America has seen many alarming invasions—the San José scale, European corn borer, Oriental peach moth, alfalfa weevil, Japanese beetle, Mediterranean fruit fly, elm disease, blister rust, chestnut-bark disease, wart disease of potatoes and many others.

It is no wonder that, gradually, one country after another has instituted legislative measures governing the importation of vegetation of all kinds, both plants and plant products, likely to carry diseases or insect pests against which protection has become increasingly necessary.

It is of striking significance, however, that most of the diseases and insect pests mentioned, reached the Continent of North America since the adoption of such legislative measures, or the acceptance of guarantees offered by exporting countries by way of health certificates.

It is not my intention to review the efforts made by the various countries; I take it that these are well known to the group that I have pleasure in addressing; but, broadly speaking, these efforts either reflect an attitude of panic, or are mere first-aid measures to bring about what was thought to be a measure of safety and protection. While measures to control plant diseases, insects, or pests, bring profitable returns to those who practice them,

[1] Contribution No. 451 from the Division of Botany, Experimental Farms Branch, Dominion Department of Agriculture, Ottawa, Canada. Presidential address presented before The American Phytopathological Society, in session, 27th annual meting, St. Louis, Mo., Dec. 31, 1935 to Jan. 3, 1936.

[2] Dominion Botanist, Department of Agriculture, Ottawa, Canada.

it is evident that they are carried out primarily for personal gain, and rarely to protect the resources of a neighbor or a community. Nor do I believe that such control measures are voluntarily practiced for patriotic reasons; that is, to protect the resources of the country. Measures taken with this object in view are usually the result of more or less forceful persuasion.

When it comes to the question of carrying out control measures solely for the purpose of protecting the resources of a foreign country, interest seems deplorably to be lacking, yet there exists hardly a problem in the realms of phytopathological endeavor the importance of which is so world-wide, and calls for such urgent, competent international effort, as the problem under discussion.

One of the first more concerted international attempts was made when representatives of the principal nations met in Rome as long ago as 1914, to discuss these problems. It was a laudable, but, as far as results were concerned, rather a futile attempt on the part of the International Institute of Agriculture, to bring the nations together. It was at that time realized that independent action by the nations seeking to protect their resources had brought about chaos, or, at least, an impasse; so the time was considered opportune for the consideration and adoption, if possible, of sounder and more logical principles or of the fundamentals of legislative measures that would prove acceptable as a basis for international action and coordination of effort.

I am impressed with the great divergence of opinion expressed at this Conference and with the scant results it has brought about. At any rate, the articles laid down at this Conference do not appear to have been ratified by the countries of the continent of America, notably Canada and the United States.

The solution of this problem—if a solution is practicable—throws a mutual responsibility upon every country, and as much as it is the aim of a country to protect its own resources, so it becomes the duty of competent plant pathological services to protect the resources of other countries, an attitude that has not always been very keenly observed.

A considerable amount of experience is necessary to deal with the perplexing problems constantly arising, and no doubt the Rome convention would have achieved considerably more had the wider experience of today been then available. But, even though the assembled nations at Rome in 1914 met with many difficulties, there exists no reason to postpone further attempts indefinitely. Valuable experience has been gained in the intervening years and the time seems opportune to plead for renewed international consideration of the problems in which all nations are vitally concerned.

The only feasible measures of protection are those based upon biological principles—a principle that is universally accepted by the technical experts —and that primarily aim at a thoroughly satisfactory protection of any and every country's agricultural, horticultural, and vegetal resources, without subjecting any one nation to further risks or expenditures, or leading them into difficulties generally in regard to trade and commerce. Such results can be achieved only when all countries alike are prepared, and—above all—properly organized, to assume their share of responsibility, not only in seeking to protect their own resources, but the resources of other countries, as well.

I. PLANT QUARANTINE LEGISLATION: A REVIEW

Aside from a number of minor or specific ordinances, there are at the present day three outstanding measures in operation, which, it was hoped, would bring about satisfactory results, *viz.*: the total embargo, health certificates and restrictive measures. The first is an attitude of watchful waiting; the second an attempt to throw the sole responsibility upon the exporting nation, without due regard to the need for protection of importing nations; and the last a more or less happy compromise of the other two.

1. *Embargoes Generally.* It is only in rare instances that a country resorts to the prohibition of importations of the commodities in which we are interested unless it has had some definite experience with a particular disease or insect pest. In most cases an embargo is the result of a more or less serious experience that a country has had and against the repetition of which it desires to protect itself. In rarer instances, a group of countries, suitably located geographically, will agree among themselves to place an embargo against other countries and their products that may involve them in serious losses. I shall return later to the question of groups of countries.

Usually, the detection of a disease or pest suspected of foreign origin—and which pests or diseases are not nowadays considered of foreign origin? —will lead to an embargo. I should like, at this point, to refer to the regrettable eagerness shown by some investigators to brand a newly discovered disease or insect pest as of foreign origin. I maintain that this attitude is unworthy and illogical and one that cannot too strongly be deprecated. In a country that is comparatively virgin as regards taxonomic studies, a disease newly reported may not be one of recent introduction, but may have existed, unknown, in the country for many years. Taxonomic studies have been carried on, especially in Europe, for a century or so and that the "new" disease has been described there is of little significance. To think otherwise verges perilously on the absurd: "*Post hoc ergo propter hoc,*" and it is still more to be regretted that this attitude, once adopted, is not readily abandoned, even after the discovery that the new "foreign" disease had been in the country for years. To anticipate my critics I wish to state

that I am quite aware that certain diseases, insects, and pests have been introduced from one country into another, and may justly be regarded as of foreign origin.

To return to the question of embargoes. There are a number of completely justifiable embargoes in force today and careful consideration may lead to others. Why, for instance, should Canada and the United States have imported seedlings of native trees such as *Pinus strobus, Pseudotsuga douglasii,* of *Larix laricina* and other genera—by means of which some new diseases or pests have actually been introduced? In the case of blister rust of five-leaf pines it seems extraordinary, that notwithstanding the abundant records at our disposal of the disastrous effects of this rust on white pine introduced into Europe from this Continent, importation of white pine nursery stock was carried on until—alas—this destructive disease gained a firm foothold both in the United States and Canada, leaving little hope for its extermination. In many cases the embargo has come too late. Furthermore, there is this very important question: Does an embargo effectively protect the resources of a country? Is it practicable, with modern facilities of transport, to guard effectively against pests or diseases by this means or to supervise adequately all methods of importation? As a matter of fact, even though embargoes have been instituted and maintained by all practical means, convincing and abundant evidence exists, that certain insects, pests and diseases have become established in the country maintaining the embargo. We have recent evidence that diseases and pests have been brought into a country by vegetation not intended for propagation. Plant products are now used industrially or for manufacturing purposes to a much greater extent than before and to make an embargo completely effective by closing all channels through which desirable or destructive diseases or pests may be introduced seems as economically difficult as it is practically impossible. No one could possibly have anticipated that manufacturers of furniture veneers would, innocently enough, cause the introduction of the European elm disease into North America by means of "burls" (knots) or elm logs used for the manufacture of veneer.

Europe has had for many years an embargo against potatoes from countries where the Colorado beetle existed, but the Colorado beetle has finally made its entry into European territory. The entry, apparently, was not made by means of potato tubers—but Europe persists in maintaining the embargo.

There exists a further aspect to embargoes. Only in rare cases may topographical location assist, as in the case of islands or areas protected by mountain barriers, etc., and though it is true that many diseases and pests have been introduced into other countries by the commodities at present subject to certification, the more recent epidemiological studies have thrown an en-

tirely different light upon the situation, by indicating vitally important factors over which one cannot hope to exert any material control.

The researches at our Winnipeg Laboratory in connection with stem rust of wheat have conclusively proved that the spores of this rust may be carried in the air for tremendous distances and at surprising altitudes. In certain years, stem rust no doubt winters over in the southern States of America, and spores are carried northward until they eventually reach our own grain-growing areas in Canada. You are no doubt familiar with the technique followed in which aeroplanes and ground spore traps played an important rôle, detailed accounts of which have been published.

While this phase of research is perhaps second to none in regard to accuracy and deduction, there exists little doubt that the time has come for further intensive epidemiological studies in which all nations should definitely cooperate. In view of the results obtained, there is little doubt that other diseases, insects and pests, have been dispersed in a similar manner—let me just instance the sudden and wide-spread outbreak of oak mildew in Europe some years ago. If such occurrences are more frequent than our present knowledge would indicate, embargoes may certainly be limited in their effectiveness. Thus, on a continent like Europe, the many international boundary lines do not constitute the slightest barrier, and embargoes between countries of one continent cannot serve the object for which they have been devised. These investigations clearly indicate the importance of a change in attitude and the substitution of entirely different methods from those relied upon at present. But with this I shall deal later.

There is a further aspect of embargoes, less biological in nature it is true, but one that has elicited frequent criticisms, *viz.*, that embargoes may be placed, and no doubt actually have been placed in many instances, to exclude commodities from a market in order to gain a trade advantage.

This also is emphasized by Dean Hutchison of the College of Agriculture of the University of California, who remarks that "such procedure is not an honest application of the principles of plant quarantine," and I think we may leave it at that. Should political or economic expediencies require an effect of this kind then the matter could be more honestly dealt with by tariff boards or similar organizations. There is this suspicion, though, in the minds of many—a suspicion almost impossible to confirm, but which might be allayed by an international council of arbitration to assist in deciding whether any such embargo may be warranted for strictly biological reasons.

Several countries have taken the lead recently in removing embargoes when it was shown that biological reasons no longer existed for them. In this connection it may be stated that not so many years ago nursery men and related interests strenuously opposed plant quarantines, claiming that they interfered seriously with their business transactions. The measures, how-

ever, proved to be a valuable means of protection for that industry, and subsequent proposals to modify them to bring them more in harmony with biological principles were opposed just as strenuously by the same interests.

It will be seen that the question of embargoes is exceedingly far-reaching and one that requires unbiased and serious consideration in the near future, since their enforcement does not always achieve the expected results.

2. *Health Certificates.* Much has been said and may be said on the subject and value of health certificates, particularly of the type in common use today. A careful consideration of all the relevant facts and experiences suggests that the guarantee attached to the certificates by the services issuing them has but little value. The laxity with which some of them are issued, or the indifference in regard to their true meaning, would indicate that facilitation of export seems the main issue involved. For it has long been the somewhat apologetic practice to certify that a consignment is "reasonably or apparently free from" or has "been examined by an authorized inspector who failed to find any evidence of" any (specified or not specified) diseases, insects, or pests. These reservations clearly indicate the limitation of health certificates and merely endorse the fairly universal opinion that they are only instruments of relative guaranty; exporting countries being more convinced of their value than importing countries.

It is admitted by any one who has had experience in the examination of vegetation, plants, or plant products, that it is not possible to issue a health certificate with any degree of accuracy, indicating that a consignment of nursery stock, bulbs, scions, cuttings, etc., is free from even specified diseases or pests, apart from any that are not specified. Certification usually takes place immediately prior to export, and since export of these commodities is crowded into comparatively short periods of time, the rush militates against thorough examination. Moreover, most of the diseases and many pests are of microscopic nature; many of them are dormant in a dormant vegetation, or may require definite periods of incubation before showing signs of their presence (as for instance blister rust of white pine), conditions that render certification extremely difficult and decidedly uncertain.

Furthermore, the most careful inspection immediately prior to export, *i.e.*, after nursery stock has been removed from where it grew, or after bulbs, etc., have been harvested, is scarcely more reliable than one made at the port of entry. As a matter of fact, all vegetation, plants, or plant products exported from one country to another, should be free from any disease or pest. No one would deliberately introduce nursery stock or similar material covered with oyster shell bark louse or Nectria fructifications, or their roots affected by nematode galls, even though these troubles are almost universally prevalent in countries of similar environmental conditions, especially when vegetation free from these common pests may be available. The inadequacy

of certification before export becomes still more obvious when the prevalence of seed-borne diseases is considered. Certification has never been applied to "agricultural seeds," mainly because of the opinion that such application would seriously interfere with trade, biological necessity being completely disregarded. Without wishing to cause undue alarm, I may state here that recent investigations conducted in our own laboratories and elsewhere have clearly revealed that even "elite" seeds may carry destructive diseases. This disturbing discovery may cause an entire change in attitude in reference to seed production and seed certification. It is the plain duty of plant pathologists in every country to combat diseases of all kinds, and to dismiss an important factor in the dispersal of plant diseases as one about which nothing can be done is an admission of failure. Indeed, during more recent years, this question has received considerably more attention from countries whose resources have been gravely endangered by diseases, and, to a lesser degree perhaps, by insect pests, introduced through seed; such diseases, for example, as blue mould of tobacco, cotton wilt, bacterial wilts or diseases, loose smuts, flag smut, and bean or pea spots. The present system of certification, however, cannot very well be applied for seed-borne diseases. The problem is a difficult one but of such economic significance that it demands precise and immediate study.

Another problem that also renders the present method of health certification obsolete, has arisen during recent years, and is of equal, if not greater, economic importance. I have reference to virus diseases affecting plants. The importance of considering immediate action in regard to these diseases was recently brought to our attention in the case of a serious virus diseases detected in *Iris tingitana* imported from Europe and in *Lilium longiflorum* from the Far East. Other virus diseases in dormant bulbs also are known. Narcissus species and varieties, notably the variety Lucifer, apparently is never free from a mosaic. "Breaking" in tulips, constitutes a menace to growers of self colors, and many more instances of more recent manifestation might be quoted. This virus problem hardly requires discussion, since it is obvious that no present health certificate is of the least value in this connection and that entirely different practices will have to be substituted.

3. *Conditional and Restrictive Measures.* These measures are largely a compromise between total embargoes and usual health certification, and may be said to meet many cases most satisfactorily. They, at least, offer a guaranty by rightly placing very definite responsibilities upon the plant pathological services of a country; a guaranty, for instance, that certain diseases or pests are not present in a country at all, or not in any defined district or territory thereof, or have not been present for a stated number of years or within a certain radius whence they originate. Yet these measures are equally subject to abuse and the provisions may be so severe or impractical

that they amount to an embargo. Personally, I consider the honest application of such restrictions as a sound policy—one, at least, of "the open door" and one likely to stimulate more competent and efficient inspection services in all countries.

Indeed, it would be a wise policy to devise means to stimulate the phytopathological services of any country to greater and more efficient effort that will result in an advancement of trade rather than interference with it—an action that would immediately commend itself to any government and thus cause a more ready financial support of such technical services. Just in passing it may be said that any inspectional service that can show evidence of promoting any healthy export would not find it difficult to secure support from their administrations, which today are becoming more and more reluctant to act, simply because of indications that the present measures in force are inadequate, interfere with legitimate trading, and eventually cause retaliations of all kinds.

Any critical consideration of the international phase of plant diseases, insects, and pests must eventually lead to the realization and admission that our knowledge of control measures is far from complete; and also, perhaps, that producers do not always carry out efficiently those measures that are known to be adequate. It goes without saying that if it were possible to control, or better still to eradicate, the diseases, insects, and pests that affect commodities of international trade, all regulations and restrictions would be much simplified and trade materially enhanced. As a plant pathologist, I frankly admit that the greatest of our problems, namely, the determination of effective control of plant diseases, has on more than one occasion been sacrificed to the more academic phases of research in plant sciences, in spite of the fact that our services exist primarily for the purpose of benefiting and promoting our industries.

Finally, critics of the suggestions made to further much needed reforms, should bear in mind that the difficulties that may be met in implementing the proposals may be largely due to the inadequacy of the control measures recommended, and thus emphasize the necessity for further research. They certainly do not justify the arbitrary dismissal of the suggestions on the ground that they are impracticable. Measures that are feasible as far as plant diseases are concerned should be equally applicable to insects, but the fact that the methods of the phytopathologist differ from those of the entomologist is surely no reason whatever for delaying action along a front that leads itself more readily to attack.

II. PLANT QUARANTINE LEGISLATION: A REFORM

The foregoing review has elicited a number of points that require future and serious consideration. Of the suggestions for reform that I take the

privilege to recommend, I would place foremost the organization in all countries of adequate and reliable plant disease surveys.

Plant-Disease Surveys. One of the responsibilities that countries mutually bear is the organization and maintenance of adequate plant-disease (insect pest) surveys, so that these services, if called upon, will be able to provide reliable and exact knowledge of any disease or pest and of its geographical distribution, and thus delimit areas that have remained uninvaded or have been effectively freed from it. The plant pathological service of each country should prepare a periodical report of such surveys for distribution to all countries that may be interested in any commodity to be exported. Unless such services are performed honestly and with sincerity as a measure of effective international cooperation, they will be of little value. It would seem urgent that all countries that have not already done so, should establish these services as one of the fundamental requirements for international intercourse in these commodities.

It is of interest to refer to a resolution passed by the Pan Pacific Congress held in Vancouver, British Columbia, in 1934 endorsing "the desirability of cooperation in the compilation and sharing of data relating to plant disease survey work." Obviously, opinions may differ as to what constitutes an adequate plant-disease survey, but this should cause little difficulty as long as one bears in mind that the published records should provide useful information to all countries concerning the prevalence and economic importance of diseases, insects, or pests. It would seem desirable to deal with this question from the international points of view and to arrive at last at an agreement as to what are the purpose and aim of such surveys and their records.

Material other than Living Plants. In view of the recent introduction of the European elm disease by means of elm burls imported for the manufacture of veneer, and of corn-borer larvae in broom corn from Europe and other similar experiences, it seems to be important for all countries to supervise more carefully the export of all kinds of materials of this type, including packing materials, boxes, barrels, hoops, etc., so that no product of the vegetable kingdom may become the source of establishing diseases or insect pests elsewhere. Here again discussion by an international committee of experts is most urgent.

Urgent Necessity for the Supervision of Exports. Summarizing the experiences of the past and looking towards greater cooperation in the future, it becomes obvious that all countries should make it their foremost concern and duty to prevent the export of any kind of materials, vegetation, plants, or plant products, including seeds and dormant bulbs, rhizomes, corms, tubers, etc., likely to be infected by diseases or insect pests that might prove of serious menace in any other country—or specific groups of countries.

Such action has become increasingly important in view of the nature of seed-borne and virus diseases, as I have pointed out previously.

I cannot see any other solution to this problem than the organization of competent inspection services whose primary duty is to inspect the plants, bulbs, etc., during the growing season at the actual place of growth and culture, and to issue certificates entirely based upon their findings. In order to give such services proper legal standing, it is paramount that all countries should make the necessary provisions under their respective Destructive Insect and Pest Acts, to enable them to restrict the export of all such commodities to plants found sound during the growing season, and to definitely interdict the export of diseased vegetation. The Dominion of Canada probably has taken the lead in this connection by an amendment to its Destructive Insect and Pest Act enabling the administration to make such regulations as are deemed expedient to prevent "the shipment beyond her borders" of any insect, pest or disease destructive to vegetation, and it is hoped that other countries will see the wisdom of such provision for the benefit of all countries and international trade. I think we shall all readily agree that inspection at shipping time alone is useless as a measure against virus and seed-borne diseases, and that neither the usual export certificate nor the port-of-entry inspection is of much value. In consequence, it is desirable that no country shall permit its public carriers, mail, express, or freight services (including auto and aeroplane and all other means of transport) to accept for export beyond her borders any commodity (to be defined) unless specific authorization has been given by responsible authority.

In order to facilitate supervision of export under these conditions, it is suggested that all bona fide export firms, which preferably should be the original producers, shall make application to the plant pathological service for registration. Following such application the plant pathological and entomological services shall become responsible for the thorough, periodical, and competent inspection of the commodities produced, and, on satisfactory evidence of health, shall grant to any such qualifying concern a license to export. It is impossible here to go into further details of such services and of their duties, and the conditions under which such export licenses be granted.

There is one point though to be emphasized, *viz.*: should at any time an exporter be refused a license to export, it will become his immediate duty, and be very much to his advantage, to put into practice the most up-to-date and effective means of disease or pest control, advice on which it shall be the duty of the plant pathological and/or entomological services to impart. It is obvious that such practices would very materially improve the general health condition of such commodities throughout an entire country.

As a matter of fact, I am in a position to indicate that the measure proposed has been put to a severe test with certain commodities, and it has been proved that its value greatly exceeds that of any other measure in force at present. In Canada, such procedure has been put into practice and has been maintained for some years with evident success. I refer to the seed-potato certification service, initiated primarily as a control of virus diseases, but also cognizant of any kind of potato disease. In 1915, when the service first started, certified potato fields averaged 12 per cent combined diseases; after seven years field inspection work, the average total of the three principal diseases (leaf roll, mosaic and black leg) found in all fields, had been reduced to about 6 per cent. In later years the averages were:

1923	Leaf roll .44	per cent	Mosaic 2.8	per cent
1933	Leaf roll .17	"	Mosaic .98	"
1934	Leaf roll .16	"	Mosaic 1.02	"

The many years of success of this type of service indicates its practicability and, incidentally, shows that virus diseases may be kept reasonably from increasing. Indeed, many fields are found every year that are totally free from all kinds of diseases.

Similar success has been attained in the certification of raspberries and, in other countries, of strawberries and other crops. We now contemplate the inauguration of similar services for the certification of bulbs, etc. While, no doubt, difficulties will be encountered in the early stages of such services, these should not constitute obstacles, but rather stimulate intellectual approach. The problem not only deserves but urgently calls for serious cooperative effort.

Tolerance and Standards. After the work of field and nursery inspection has been completed, the products or commodities originating from establishments passed for export, shall be further inspected and certified in regard to diseases or pests that are apparent only after digging operations (root galls, nematode infestation, scab, rhizoctonia, etc.). In this connection it may be mentioned that certain countries have (already) set more or less reasonable domestic standards and may naturally expect imported products to at least conform to these.

While it is highly desirable from every point of view to aim at the complete freedom of vegetation, plants, or plant products, etc., from diseases and insect pests, it is hardly reasonable to expect such perfection at this stage of our knowledge, and of our respective organizations. The attempt to vouch for what cannot practically be accomplished has discredited many a certification service, and we must be content to make it our first aim to protect the resources of other countries as honestly as our own. This may be commenced by devising limits of tolerance, especially for diseases and insect pests widely prevalent throughout geographical groups of countries.

Thus, countries within the temperate zone, where potato scab, rhizoctonia, oyster shell bark louse and similar troubles are universally prevalent, should mutually determine the tolerance or maximum extent of any such disease or pest that will be permitted on imports. Let me give, for instance, a tolerance allowed for potato scab:

Slight infection, where the coverage is from 1 to 5 per cent of the surface, allowed on not more than 10 per cent of the potatoes.

Moderate infection, from 5 to 10 per cent surface coverage, allowed on not more than 5 per cent of the potatoes.

Severe infection, with more than 10 per cent surface coverage, no allowance.

This standard has served our purposes quite satisfactorily in the case of the production of certified seed potatoes and is liable to be adopted throughout the continent of America as a standard for scab tolerance. It may meet the needs of other countries, too.

Similar standards of tolerance are required in regard to the more universally present troubles, and geographical situation may materially simplify such determination. Some countries have no such standards, while others have regulations that practically debar everything from being imported, so that a clear understanding seems urgently required. One experience comes to my mind where a certain country rejected a high grade of potatoes on the ground that they did not "conform to their standards," but showed 2 per cent scab, 1 per cent silver scurf (Spondylocladium), and 1 per cent Fusarium dry rot. On inquiry we ascertained that the port of entry inspection service based its decisions on the conditions, amongst others, of freedom from bacterial soft rots, "filtrable viruses" and "worm cuts." I prefer to make this statement without further comment, but the practice of this and other countries seems to confirm the opinion that these difficulties might be overcome by agreeing upon tolerance limits that are more acceptable internationally. I am quite aware of the problems that may arise in setting such standards for certain diseases and insect pests, but with the usual spirit of understanding among nations, these difficulties should not prove unsurmountable.

Port-of-entry Inspection. Just as the suggested system of field inspection and certification is bound to relieve the "pre-shipment" inspectors of a country of much responsibility, so will it relieve the port-of-entry inspection services of the sole responsibility of passing materials offered for import.

If, furthermore, all export consignments were officially tagged to identify the country of origin and the certification authorities, and were found duly in order, the port-of-entry inspector would have to examine only a certain percentage of imported material. This, indeed, is the practice today, but

it has not the measure of protection behind it that is now suggested. In the case of bulbs, rhizomes, etc., duly furnished with field inspection certificates in regard to virus diseases, the inspectors should note the destination, and request information on the quality shown by such commodities on growing or forcing—to be confirmed where necessary by an official of the service. Unless such procedure is followed, virus diseases will continue to invade new territories, and since they are undetectable in dormant vegetation, the port-of-entry inspection service will, most unjustly, be exposed to complaints and claims for having passed inferior material. It should, however, be part of the routine of port-of-entry inspection services to refer all complaints of this nature to the inspection services of the country of origin, submitting samples where possible, and requesting immediate adjustment through the producer or other liable concern. A prompt official report on the action taken should be submitted in each case.

Insurance Against Interceptions. This proposal does not directly concern plant-disease legislation but is closely related, and is submitted for consideration by the more or less purely commercial interests. Experience has shown that notwithstanding a health certificate issued by the country of export, and a "port of entry" inspection, certain classes of vegetation are often released that do not conform to the expectations of the importer. They may be free from diseases or insect pests, but may have suffered in storage prior to shipment, have become injured during transit by heating or salt water, or may be infected by viruses or other troubles not recognizable by even the most competent port-of-entry inspector. The effect is that the consignment proves of little value, and is not acceptable to the importer. Such occurrences are not uncommon. They invariably give rise to complaints, and lengthy correspondence involving expert advice, and in some cases have led to arbitrary decisions, unsatisfactory to both the exporter and importer. It is suggested that the matter be taken up with insurance companies, who may be prepared to insure exporters against such risks, covering partial or whole destruction or interceptions of this type.

Quarantine and Detention Services. Realizing that port-of-entry inspections have definite limitations, that many troubles cannot be determined in dormant matter, and that microscopical examination is impracticable because of the delay, and of the large force of inspectors that would be required to deal with the rush at seasons of import, the suggestion has been made that quarantine stations be established or, at least, provision made for more adequate detention services through which questionable introductions may be safely held for observation. This system has been practiced with success in health of animal services and it seems only logical to consider such arrangement in health-of-plants services. Indeed, such practices have been followed in some parts of the British Empire and elsewhere, notably with

citrus fruit, bananas, and sugar cane; but the value of such detention stations would be limited to the quantities that could be safely dealt with, and to very specialized plants or products. At any rate, it would seem worth while to consider carefully the feasibility of this proposal and to define the types of importation to which it would apply.

The great difficulty will always be to know how to safeguard against escapes or how to prevent the introduction of plant pests or diseases brought in by other means than living plants or products. Technically, difficulties are bound to arise. It is well known that temperature and environmental conditions generally, influence the development of microorganisms, and, unless adequate variation is provided, may give rise to the development of less important organisms, while inhibiting the growth of more serious ones. Moreover, in the case of valuable tropical orchids, competent care is essential to maintain growth, and the failure or death of any such material may involve an administration in rather costly compensation or litigation, a predicament that should be avoided at all costs. Personally, I lack experience in the operation of this system, but I fear that such undertaking may considerably add to the cost of maintenance of plant pathological services.

Agreements among Groups of Countries of Similar Interests and Geographical Location. I have already emphasized the urgency of a mutual agreement between countries on regulations governing import and export of commodities under consideration. The present impasse has seriously affected international trade, and even good will, since it has led to threats, or the actual levy, of protective tariffs on commodities other than plants and plant products. An important step to this end would be taken by the alliance of countries of identical or similar interests and of suitable geographical locations for the adoption of measures protective of the resources and interests of the whole group. Thus, the countries of North America, namely the United States of America, Canada, and Mexico, have many common interests and would mutually benefit from united action. These countries have actually had some sort of group agreement in operation for a number of years, especially relative to diseases, insects, and pests from European and Asiatic countries. Another group might be formed by the countries of Latin America, including, probably, Central America; and the countries of Europe might find it of advantage to unite to devise cooperative means of protecting its entire area from invasion of specific diseases from other continents. Some of the British overseas possessions have already such an agreement in force and have been joined by possessions, suitably located, of other countries.

I believe that such group systems would promote international understanding and good will, and are deserving of the most intensive study.

International Cooperation in Scientific Research. I have repeatedly referred to certain reforms that require a great deal of careful thought and

research before they can be put into operation. There cannot be any doubt that a very cordial relation has existed among the plant pathologists of the world, but it does seem that scientific efforts should be more closely coordinated, particularly in its bearing upon the perplexing problems under discussion. In Bulletin 553 of the University of California, a similar thought is expressed: "Intensified efforts must be devoted to the development of methods for the treatment of agricultural commodities to free them from pests and diseases to the end that they may move freely in the channels of commerce, in this way removing so far as possible the necessity for embargoes. In this direction lies one of the most important possibilities of reducing plant quarantines; carriers thus forestalling serious interferences with the marketing of crops and the same time preventing so far as reasonably possible the spread of dangerous pests and diseases."

It may be said that international effort has been materially assisted by the dissemination of information through periodicals and the more or less critical abstracting journals; but its success depends largely upon the close contact of the research workers themselves. To promote this association and at the same time to obtain the greatest amount of benefit from the work accomplished, every facility should be given to the international exchange of workers specifically charged with duties pertaining to plant quarantines. The question of accepting, with safety, the verdict of an official is decided largely upon individual reputation that he has established, and to know, personally, the responsible officers in charge of these services in the various countries would be of distinct advantage and would aid in cooperation.

This exchange of workers has been the practice in related services in the British Empire and the United States, and any administration would be well advised to send its technical experts from time to time to other countries to become familiar with the way specific disease problems or pest control are handled. Considerable saving may eventually be effected by this policy, as much expenditure in speculative fighting of foreign pests or diseases may be avoided. Indeed, it would be worth while to consider the advisability of attaching competent officers to the consular services in the principal countries from which imports are drawn, so that specific information on foreign diseases may be readily available from experts familiar with such problems.

Remarkable progress has been made during the past decade or so in relation to breeding plants resistant to certain diseases and in regard to biological control of insect pests. While in this latter aspect, international cooperation has been developed to an appreciable extent, it is doubtful whether similar cooperation exists in the interchange of vegetation resistant to diseases—or, incidentally, to drouth and frost. Furthermore, since the days of 1914, there has been much work done on biological or physiological strains or races. In Canada and the United States particularly, much progress has

been made in the study of physiological specialization of stem rust of wheat; and at present several varieties of wheat that are quite immune from this most serious of all rusts are being propagated for distribution. We know, however, of the existence of strains of rust in other lands, the introduction of which would seriously compromise our efforts to produce a resistant variety of wheat for our conditions. So far we have, with one exception, only comparatively harmless strains of crown rust of oats, but other countries have forms, which, if introduced into Canada, might cause serious losses. As far as we know we have no physiological specialization in Phytophthora, but in Germany such races have been discovered.

This introduces an additional phase for international cooperation, *viz.*: Research on the behavior of plants, immune from the physiological strains of one country, to those of another, and the application of the knowledge gained to the problems involved. Any cooperation dealing with the testing of native crop plants in a foreign environment to determine their reaction to diseases not yet known in the country of origin is much to be advocated. To some limited extent such cooperation has been actually put into practice between the United States and the Dominion of Canada in an attempt to learn something of the reaction of species of Grossularia and Ribes native in California and along the Pacific Coast of the United States to *Cronartium ribicola*, which has been prevalent in the limited five-leaf pine resources of the Canadian Province of British Columbia.

The question of epidemiological studies has been referred to previously, and it would seem to me that this problem, too, is one for international cooperation. Attempts to determine the fungus spore content of the air between ports of Canada and Great Britain have been made, many times on steamships, and also on the British dirigible R100 during its first flight over the Atlantic, for there are so many striking instances of the sudden arrival of diseases or pests in often remote sections of a continent, that the distance flight of fungus spores may well account for them.

The problems of virus and seed-borne diseases have not received the attention they demand, although some work has been done on them in certain countries. Even though these problems are complicated, they should not be neglected, and if the reforms I have suggested prove to be acceptable, solutions should not be impracticable. Both problems should encourage cooperation among the plant pathologists of the world.

International Advisory Council on Plant Quarantines, Suggested. Countries that export extensively have felt the economic consequences of quarantines very keenly; far more so, of course, than countries with restricted exports. It is surprising to find countries maintaining many restrictions or embargoes that are biologically quite unsound or, at least,

unreasonable. This attitude has caused many a country real concern, and in some instances has led to retaliatory measures that have not improved the relations between countries. The administrations of many countries feel that plant quarantines of the present day are more or less a serious nuisance, but few of them have shown a readiness to support the maintenance of a responsible international council to review from time to time the whole progress made in this connection and to suggest improvements to facilitate international trade in these commodities. Some such attempts have been made from time to time, but I am not aware of any active interest that has been taken in the attempts by the governments of many countries. It is, therefore, suggested that such an advisory council should be subsidiary to some outstanding organization of international repute, and I certainly think that the Council of the League of Nations should be officially requested to promote an organization of this type with well-defined duties as indicated by the many problems and difficulties confronting us. The League of Nations has actually, as occasion warranted, appointed committees of experts to consider similar problems, as, for example, the "International traffic in animals and animal products." It is pointed out in a report of this committee, that, if one nation controls or eradicates any particular disease, a benefit is thereby conferred on all nations, while its presence inhibits or restricts international traffic. This, exactly, is the well-established principle upon which the suggested reforms are based. Since the first attempt was made in 1914 for international action in reference to diseases and pests affecting plants and plant products, a sufficient period of years has elapsed and considerable experience has been gained, to enable the problem to be examined in a true perspective. "In the League of Nations and the expert committees which the League may appoint, there exists the required potent agency to bring about that international cooperation which is such a dominant factor in the success or failure of the campaign against disease." It is to be hoped that international consideration may be given to our problems in the near future, for the continuation of our present practices will make future contacts among nations still more difficult.

In conclusion, it may be of interest to record that action was taken both by the plenary sessions assembled on the occasion of the Sixth International Botanical Congress, Amsterdam, 1935, and the American Association for the Advancement of Science, St. Louis, 1936, in forwarding the following resolution, which I had the honor of proposing on both occasions:

The members of Section: Phytopathology express themselves of the opinion: "that an effective and unceasing campaign against destructive plant diseases, insects and pests can only be successfully prosecuted by international action and mutual cooperation . . .

"that close and frequent international discussion of the problems of plant quarantine should take place to bring about improvement of the health conditions of plants and plant products offered for export,

"that they unanimously recognize that such action will greatly facilitate international trade in the commodities concerned; and

"that, finally, the matter shall be brought officially to the attention of the League of Nations with the recommendation that the matter receive the careful consideration of that organization, with a view to facilitating and expediting the purposes and aims of this resolution."

REPORT OF THE TWENTY-SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

THE ST. LOUIS MEETING

The American Phytopathological Society held its 27th annual meeting at St. Louis, Mo., from December 31, 1935, to January 3, 1936, inclusive. Headquarters were at the Statler Hotel. Sessions were held at Washington University. The meeting was well attended. About 160 members and 50 visitors registered. For the first time, by decision of the Council, the meetings were extended over 4 days instead of 3 in order to relieve program congestion. Speakers also were held to time, a requirement that met with unanimous approval, since it afforded more opportunity for discussion.

The program was of outstanding interest and value. There were 132 papers and addresses presented in 14 sessions, including joint sessions held with Section G of the American Association for the Advancement of Science, the Mycological Society of America, the Genetics Society of America, and the Potato Association of America. These joint sessions were much appreciated for the stimulating viewpoints and broad perspective contributed by the representatives of different scientific and applied fields. The programs of the joint symposium type proved so worthwhile that their continuance appears highly desirable.

The address of the retiring President, H. T. Güssow, entitled "Plant Quarantine Legislation—A Review and a Reform," surveyed in an exceptionally clear and penetrating way the problems of international plant protection and suggested measures aiming at more effective safeguards against disease hazards with less interference with normal international commercial relations. This address was ordered printed in PHYTOPATHOLOGY.

On Wednesday afternoon a conference on coordination of plant disease research and extension was held by the Extension-Research Committee, R. J. Haskell, Chairman. Over 50 were in attendance. The discussions, led by different members of the committee, outlined definite needs for research attack on practical control problems with which the extension workers are confronted in connection with cereals, potatoes, fruit, vegetables, and ornamentals, and presented specific ways in which research and extension men can be of direct mutual assistance. The Conference voted that a committee be appointed to crystallize in the form of a resolution the strong general conviction of the necessity for regional coordination in developing disease-control programs and for regional conferences to bring this about. E. C. Stakman, J. C. Gilman, and R. H. Porter were appointed and the resolution prepared by them was adopted by the Society at the final business session. It was the sentiment of those present that another extension-research conference should be held at the next annual meeting.

On Thursday evening, a well-attended plant disease survey conference, led by H. A. Edson, discussed practical means of obtaining more systematic, more complete, more accurate, and more continuous (from year to year) records on the distribution, severity, and extent of damage from plant diseases. This was followed by a symposium on antibiosis in which M. N. Levine, G. B. Sanford, and R. Weindling analyzed the complexity of the factors involved in the suppression of plant parasitic organisms by other microorganisms. There was lively discussion afterward. Over 150 were in attendance. The Society's representatives at the Sixth International Botanical Congress at Amsterdam then presented a report and the Committee on Foreign Plant Diseases took charge of the remaining discussions of the evening, which revolved around plant protection problems and led to a

series of important resolutions, later presented to the Society and adopted at the final business meeting.

The annual phytopathological dinner was held Tuesday evening in the Statler Hotel, with almost 250 in attendance, with President H. T. Güssow as toastmaster. An interesting program, celebrating the completion of 25 years by the Society's journal, PHYTOPATHOLOGY, had been arranged by L. R. Jones with the other editors in chief assisting. Stimulating messages were read from L. R. Jones, Donald Reddick, and Perley Spaulding, who were unfortunately prevented from attending. The past achievements of the journal were discussed interestingly by H. B. Humphrey, and E. C. Stakman threw out a vigorous challenge to the membership of the Society to work together to the end that PHYTOPATHOLOGY may meet her problems successfully and serve with increasing effectiveness the field of science in the interest of which she was created. A committee of the Minnesota members of the Society arranged for a good Negro quartet and for certain special entertainment features. Twenty-five candles were lighted before the 25 volumes of the journal set in front of a painted background portraying artistically in colors some of the chief milestones in her quarter century of progress. Those present likewise greatly enjoyed the artistic vocal rendition by a group of members of a series of appropriate humorous songs introduced between the talks.

OFFICERS, REPRESENTATIVES, AND COMMITTEES FOR 1936

Those whose names are followed by an asterisk (*) were elected or their appointments were confirmed by the Society at this meeting.

President, G. H. Coons*, U. S. Department of Agriculture, Washington, D. C.

Vice-President, Carl Hartley*, U. S. Department of Agriculture, Washington, D. C.

Secretary, Howard P. Barss, U. S. Department of Agriculture, Washington, D. C.

Treasurer and Business Manager of PHYTOPATHOLOGY, H. A. Edson, U. S. Department of Agriculture, Washington, D. C.

Editors, Editor in Chief of PHYTOPATHOLOGY, H. B. Humphrey, U. S. Department of Agriculture, Washington, D. C., H. M. Quanjer, Annie Rathbun Gravatt, Eubanks Carsner.

Associate Editors (3 years), T. E. Rawlins*, C. L. Lefebvre*, Edna M. Buhrer*, Corabel Bien*, G. B. Sanford, A. H. Eddins, A. G. Newhall, R. P. White, F. O. Holmes, G. G. Hahn, J. J. Christensen, F. L. Drayton.

Advertising Manager of PHYTOPATHOLOGY (1 year), R. S. Kirby*, Pennsylvania State College, State College, Pa.

Councilors, N. E. Stevens* (2 years), University of Illinois, Urbana, Illinois; J. C. Walker (1 year), University of Wisconsin, Madison, Wisconsin; H. T. Güssow (1 year), Central Experimental Farm, Ottawa, Canada; V. H. Young* (1 year), University of Arkansas, Fayetteville, Ark. (representing the Southern Division); and T. E. Rawlins* (1 year), University of California, Berkeley, California (representing the Pacific Division).

PHYTOPATHOLOGICAL CLASSICS: *Editor*, H. B. Humphrey; *Business Manager*, H. H. Whetzel.

Representatives on the A. A. A. S. Council (1 year), N. E. Stevens*, H. S. Cunningham*.

Representative, Division of Biology and Agriculture, National Research Council, Howard P. Barss.

Representatives on Board of Governors, Crop Protection Institute (3 years), J. F. Adams, W. H. Martin, C. R. Orton*.

Representative on the Tropical Research Foundation (5 years), L. R. Jones*.

Representative on Subsection of Phytopathology, International Union of Biological Sciences, Donald Reddick*.

Representative on the Board of Editors, American Journal of Botany, G. W. Keitt*.

Committee on Foreign Plant Diseases, C. R. Orton, H. T. Güssow, J. S. Boyce, W. A. McCubbin, R. D. Rands.

Committee on Extension and Research, Chas. Chupp, R. J. Haskell, A. L. Pierstorff, R. S. Kirby, E. C. Stakman*, G. W. Keitt*, W. B. Tisdale*, I. L. Conners*.

Committee on Permanent Endowment, E. C. Stakman, J. G. Brown, H. H. Whetzel, A. J. Riker, L. R. Hesler.

Committee on Investments, H. A. Edson*, N. E. Stevens*, Chas. Brooks, F. C. Meier*, J. W. Roberts*.

Necrology Committee, A. G. Johnson, G. P. Clinton, M. B. Waite.

Committee on Coordination in Potato Disease Research, J. G. Leach*, J. C. Walker*, R. W. Goss*, D. Reddick*.

Committee on Coordination in Seed Treatment Research, C. S. Reddy*, W. E. Brentzel*, M. B. Moore*, H. A. Rodenhiser*.

Committee on Publication Problems (to be appointed).

TEMPORARY COMMITTEES APPOINTED IN 1935

Committee on Elections (appointed by President Güssow for the St. Louis Meeting), N. J. Giddings, L. H. Leonian.

Auditing Committee (appointed as above), R. J. Haskell, N. E. Stevens.

Committee on Resolutions (appointed as above), L. W. Durrell, V. H. Young, E. E. Clayton.

Official Committee to Represent the Society before the International Union of Biological Societies and the Sixth International Botanical Congress, Amsterdam, September, 1935 (appointed by the Council), H. T. Güssow, Donald Reddick, N. E. Stevens; alternates, J. C. Walker, E. C. Stakman.

REPORT OF THE SECRETARY FOR 1935

The Secretary has performed the usual duties of the Office and in this work has been greatly helped by the former Secretary-Treasurer, F. C. Meier, and by Mrs. Meier, who has continued to handle the membership records, journal mailing list, and other business with efficiency and dispatch. The other officers and members of the Council have participated actively in the work of the Society; and the President for the year 1935, H. T. Güssow, devoted an unusual amount of time and attention to constructive effort in the interest of the purposes for which the organization exists. Appreciation also must be expressed for the democratic way in which various members of the Society have showed their interest in its work by sending in to the Secretary at various times useful suggestions and criticisms for the consideration of the Council. It is hoped that this excellent practice may become traditional with the Society, as it will promote progress and maintain effectiveness.

Membership. The Society started the year 1935 with 798 members and ended it with 832, a net gain of 34. Sixty-two new members were elected at the St. Louis meeting, the largest group in recent years, and 12 former members were restored to the active roll during the year. The Society lost 40 members during the year, 13 by resignation, 3 by death, and 24 by suspension for non-payment of dues. Of the full membership, 107 are paid-up life members and 60 are still paying $10 per year toward life membership. New applications for this type of membership are no longer being accepted by the Society, in view of action taken at the Atlantic City meeting in 1932.

HOWARD P. BARSS, *Secretary.*

REPORT OF THE TREASURER

Statement of Accounts for the Year Ending November 30, 1935

Receipts:

Balance from 1934			$1,687.16
Annual dues:			
1931	$ 5.00		
1932	10.00		
1933	20.00		
1934	50.00	($ 20.00, life)	
1935	2,447.50	(360.00, life)	
1936	1,646.20	(350.00, life)	
1937	20.00	(20.00, life)	
1938	20.00	(20.00, life)	$4,218.70
Sales included in check for dues			0.60
Lyman Fund included in check for dues			2.00
Total receipts			4,221.30
			$5,908.46

Expenditures:

Member subscriptions transferred to PHYTOPATHOLOGY			
1934 and earlier	$ 60.00		
1935	2,628.82	$2,688.82	
Transferred to Sinking Fund (Savings Account and Building and Loan)		330.00	
Secretarial work for Treasurer, Secretary and Business Manager		354.14	
Printing (programs, ballots, etc.) and mimeographing		162.10	
Stamps and envelopes		68.99	
Supplies		15.90	
Telephone and telegraph		17.29	
Expenses of Secretary-Treasurer, Pittsburgh meeting		56.26	
Service charge by bank		5.30	
Federal tax on checks		0.22	
Total expenditures			$3,699.02
Balance on hand, November 30, 1935			2,209.44
			$5,908.46

Sinking Fund. At the close of 1934 the Sinking Fund, obtained by deducting $5.00 (formerly $6.00) from each $10.00 life-membership installment, totaled $8,321.00. On July 1, 1935, this amount had increased to $8,486.00, of which $5,000.00 was invested in first mortgage notes at 6% and $3,486 was available for investment. A greater part of this latter amount was at that time drawing interest of 1% in a savings account, and a small part ($305.00) had not been transferred from the checking account of the Society, where it drew no interest. Later in the year, an additional $25.00 accrued from 1935 life-sustaining dues, making a total of $3,511.00 available for investment during the year. It was desirable that this amount be invested with a view to both a higher rate of interest and safety for the Society's funds. In consultation with the investment committee the Treasurer invested $3,500.00 with building associations, and the balance of $11.00 has been deposited in a savings account.

The total interest from the Sinking Fund is available for publication of PHYTOPATHOLOGY. During 1935 this amounted to $472.50.

The Lyman Memorial Fund for the permanent endowment of PHYTOPATHOLOGY

On hand Jan. 1, 1935	$1,945.95
Contributions to the fund during the year	180.29
Interest and dividends accumulated during the year (including $47.73 interest of Jan. 1, 1936)	97.29
Total on hand Jan. 1, 1936	$2,223.53

(*Note:* At the St. Louis meeting contributions and pledges to the Lyman Fund from the Minnesota group amounting to $150 were announced.)

H. A. EDSON, *Treasurer.*

REPORT OF THE BUSINESS MANAGER OF PHYTOPATHOLOGY

Statement of Accounts for the Year Ending November 30, 1935

Receipts:

Balance from 1934		$1,246.82
Subscriptions:		
1933	$ 7.25	
1934	56.60	
1935	3,054.78	
1936	468.49	$3,587.12
Member subscriptions, 1934 and earlier		60.00
Member subscriptions, 1935		2,628.82
Sales of back numbers		339.94
Advertising:		
1934	$209.85	
1935	564.65	774.50
Interest on 1st mortgage notes		300.00
Interest on Sinking Fund Savings Account		56.51
Classics included in check for sales		2.00
Insurance premium refunds		25.54
To replace check returned by bank		6.00
Total receipts		7,780.43
		$9,027.25

Expenditures:

Printing and Distributing PHYTOPATHOLOGY:		
Vol. XXIV, No. 11	$663.22	
No. 12	395.24	
Index to Vol. XXIV	325.17	$1,383.63
Vol. XXV, No. 1	763.83	
No. 2	676.21	
No. 3	561.97	
No. 4	477.45	
No. 5	387.61	
No. 6	562.45	
No. 7	305.63	

No. 8	430.01		
No. 9	478.80		
No. 10	193.39		
No. 11	391.65	5,229.00	
Postage		646.66	$7,259.29
List of members of American Phytopath. Soc.			146.00
Preprints of abstracts			49.46
Secretarial work for Business Manager			105.73
Secretarial work for Editor in Chief			409.17
Expenses of office of Editor in Chief			47.50
Secretarial work for Advertising Manager			18.00
Commission and expenses of Advertising Manager			129.84
Stamps and envelopes			97.66
Supplies			10.65
Storage of back volumes			48.00
Transfer, back volumes U. of Md. to Lancaster			11.47
Printing (subscription bills)			21.00
Use of car, trip to Lancaster of Business Manager and Editor in Chief			12.50
Labor, special sale of 1933, 1934			6.82
Telegram			.40
Classics, transferred to H. H. Whetzel			2.00
Phytopathology distribution			1.07
Check returned by bank			6.00
Service charge by bank			1.45
Federal tax on checks			.08
Collection charge on check			.35
Total expenditures			$8,384.44
Balance on hand, Nov. 30, 1935			642.81
			$9,027.25

Non-member Subscriptions. At the end of 1934 there were 541 non-member subscribers to PHYTOPATHOLOGY, including 7 complimentary subscriptions. During the year 1935 there were 23 cancellations and 24 suspensions for non-payment, a loss of 47, but with 74 new subscriptions the net gain was 27, increasing the list at the close of 1935 to 568. It is interesting to note that only 175 of these are domestic, while we have 393 foreign subscriptions on our list. Japan leads with 57, the U. S. S. R. has 42, England 35, and Canada 27.

H. A. EDSON, *Business Manager.*

REPORT OF THE AUDITING COMMITTEE

In auditing the accounts for the year ending November 30, 1935, the books of the *Treasurer of the Society* and the *Business Manager of Phytopathology* have been examined and the receipt and expenditure vouchers compared with the entries. All receipts are supported by the bank deposit slips and all expenditures are supported by receipted bills or cancelled checks, usually by both. We find the books in excellent order and believe them to be correct.

In addition, we have reviewed the investments of the *Sinking Fund* and find them to be as follows:

First mortgage notes deposited with the McLachlen Banking Corporation for collection	$5,000
Invested with the following building and loan associations:	
Northwestern Savings & Loan, at 5%	1,000
National Permanent Building Association, 5%	500
District Building and Loan, 5%	1,000
Columbia Permanent Building Association, 5%	500
Perpetual Building Association, 4½%	500
Deposited in Savings Account with McLachlen Bnk. Corporation	11
	$8,511

We also have reviewed the investment of the *Lyman Memorial Fund*, which is on deposit in the Brookland Building Association and amounts to $2,175.80.

December 28, 1935.

NEIL E. STEVENS,
R. J. HASKELL.

REPORT OF THE EDITOR IN CHIEF OF PHYTOPATHOLOGY

The 25th volume of PHYTOPATHOLOGY, issued in 1935, contains 1,118 pages of printed text and illustrations (266 less than Volume 24) classified as follows: Eighty articles, 35 phytopathological notes, 3 reports of regional or other meetings, 6 book reviews, 169 abstracts (4 by title only), and 152 text figures, and 5 plates. During the period January 1 to December 31, inclusive, approximately 148 manuscripts of articles, phytopathological notes, reports, book reviews, etc., and 167 abstracts (4 by title only) were submitted. Of this number, 10 major manuscripts and 2 minor articles were returned to their authors for revision, 2 were withdrawn by their authors. Of the manuscripts submitted in 1934, but too late for publication that year, 3 were returned in the current year for revision. In addition to the papers published this year, 23 articles, 2 phytopathological notes, 1 national report, and 108 abstracts (1 by title only) are now, December 31, in press. The index for Volume 25 was published as a supplement to the June, 1935, number of PHYTOPATHOLOGY. The list of members of The American Phytopathological Society was pubiished as a supplement to the May, 1935, number of PHYTOPATHOLOGY, and the Constitution of The American Phytopathological Society was published in the April, 1935, number.

A subject foremost in our thought concerning our journal relates directly to its adequate financial support. Since this will come up for detailed consideration later, I shall here merely observe that, unless our printing budget be increased by as much as $300.00 per month, we cannot hope to keep abreast of the steady stream of acceptable manuscripts that reach the editor's desk, once the present waiting list is reduced to a working minimum.

There is now on hand a sheaf of manuscripts of sufficient volume to fill 900 pages of our journal, and acceptable papers continue to fall into the editorial hopper at the rate of one manuscript every 2½ days; and this, notwithstanding the fact that the interval between acceptance and publication is now 10 months.

During 1935 there were published in PHYTOPATHOLOGY 13 papers, or a total of 200 pages, submitted by contributors connected with a single institution. The entire cost of printing these 13 papers was borne by that institution and, in accordance with duly

authorized editorial policy, the papers were published out of the chronological order as determined by date of acceptance.

Contrary to a misapprehension entertained by some, the printing of such publication-paid manuscripts has not and will not in the least affect the amount of space assignable to any and all others, nor the promptness with which their contributions will appear.

There has been, in general, a marked improvement in the quality of all manuscripts submitted during the current year. There is, however, room for further improvement, particularly in the matter of reducing word volume to proportions reasonably commensurate with the importance of the contribution to our knowledge of the subject of which the manuscript treats. More thought should be given to this detail than has yet been given.

H. B. HUMPHREY, *Editor in Chief.*

REPORT OF THE ADVERTISING MANAGER OF PHYTOPATHOLOGY

Fifteen concerns used PHYTOPATHOLOGY for advertising merchandise in 1935. The income of $811.59 was an 18.9 per cent decrease from that of 1934, but a 44.5 per cent increase over the advertising income of 1933.

The total number of advertisements printed was 139, of which 91 or 65.6 per cent were revenue-producing and occupied 55¼ pages. Forty-eight advertisements occupying 36¼ pages were non-revenue producing. These consisted of exchanges with other journals, space occupied by the directory of advertisers, announcements of meetings, and Phytopathological Classics notices.

R. S. KIRBY, *Advertising Manager.*

REPORT ON PHYTOPATHOLOGICAL CLASSICS

Report for the Fiscal Year from December 15, 1934, to December 16, 1935

Number of Classic No. 1 on hand 12–15–34		389
Total number sold		162
Balance on hand 12–16–35		227
Number of Classic No. 2 on hand 12–15–34		588
Total number sold		161
Balance on hand 12–16–35		427
Number of Classic No. 3 on hand 12–15–34		792
Total number sold		237
Balance on hand 12–16–35		555
Number of Classic No. 4 on hand 12–15–34		1020
Total number sold	381	
Number gratis	15	
Total number disposed of		396
Balance on hand 12–16–35		624
Cash balance on hand 12–15–34		$207.51
Total receipts from sales for year		518.25
Total cash income		$725.76

Expenditures:		
Printing of Classic No. 4	$282.83	
Postage	37.90	
Printing of cards, stationery, etc.	22.85	
Total expenditures		$343.58
Balance on hand 12–16–35		$382.18
Balance due on account		20.75

H. H. WHETZEL, *Business Manager of Phytopathological Classics.*

REPORT OF THE COMMITTEE ON ELECTIONS

Nearly 400 ballots were received. G. H. Coons was elected President, Carl Hartley was elected Vice-president, N. E. Stevens was elected Councilor for 1936 and 1937. The Pacific Division, at its last meeting, continued T. E. Rawlins as its representative on the Council for 1936. The Southern Division, at its last annual meeting, continued V. H. Young as its representative on the Council for 1936.

N. J. GIDDINGS,
L. H. LEONIAN.

REPORT OF THE COMMITTEE ON RESOLUTIONS

To the American Association for the Advancement of Science, The American Phytopathological Society wishes to express thanks for the general arrangements for the St. Louis meeting and also to C. W. Dodge, of Washington University, and his associates for working out the many details.

To the Management of the Hotel Statler, the Society wishes to express its appreciation of the many courtesies extended during these meetings.

To E. C. Stakman, and J. J. Christensen, and the members of the double quartette, the Society wishes to express appreciation for the excellent entertainment furnished at the annual banquet.

The Society also desires to thank the staff of PHYTOPATHOLOGY and the officers of the Society for their work and guidance during the past year.

L. W. DURRELL, *Chairman*,
V. H. YOUNG,
E. E. CLAYTON.

REPORT OF COMMITTEE ON NECROLOGY

During the calendar year 1935, there have been three deaths as follows:

Mr. Kinya Sasaki, March 3, 1935;
Professor Samuel Henry Essary, May 1, 1935;
Professor James M. Van Hook, June 21, 1935.

A. G. JOHNSON, *Chairman*,
G. P. CLINTON,
M. B. WAITE.

REPORT OF A. A. A. S. COUNCIL REPRESENTATIVES

Your representatives on the Council of the American Association for the Advancement of Science would report that at the St. Louis meeting the Council adopted the following resolutions of special interest to the Society: (1) Appeal for Permanent Support for International Biological Abstracts, (2) Endorsement of a Resolution Adopted at the

Sixth International Botanical Congress on the Control of Plant Diseases and Insect Pests, and (3) Endorsement of Efforts to Control Plant Diseases and Injurious Insects of Foreign Origin, Especially the Dutch Elm Disease. The latter two resolutions were based on recommendations to the Council by the Society. The full text of these resolutions appears in Science 83: 118–119, February 7, 1936.

N. E. STEVENS and H. S. CUNNINGHAM, *Representatives.*

DIVISION OF BIOLOGY AND AGRICULTRUE, NATIONAL RESEARCH COUNCIL

Your representative attended the annual meeting on April 20, 1935. Of the items considered, the one of chief interest to the Society was the problem of the continuance of International Biological Abstracts, in view of the announced withdrawal of support by the Rockefeller Foundation. A conference called December 9 and 10, 1935, to consider the problems of abstracting and documentation of scientific literature also was attended. A resolution was adopted asking the National Research Council to set up a standing committee to consider the problem of effective support of needed abstracting and indexing agencies and calling attention to the danger to research of the discontinuance of existing agencies.

On recommendation of the Division of Biology and Agriculture, based on representations by this Society and other American biological societies, the National Research Council on August 2, 1935, dispatched a communication expressing the desire of the Council to adhere to the International Union of Biological Sciences. This action made possible the affiliation of the American Phytopathological Society to the appropriate subsection of the International Union.

HOWARD P. BARSS, *Representative.*

REPORT OF REPRESENTATIVES ON BOARD OF GOVERNORS, CROP PROTECTION INSTITUTE

A summary of projects and activities for the current year is submitted for your consideration. During the year 1935 the Board of Governors consisted of the following personnel: W. C. O'Kane, Chairman, Durham, New Hampshire; W. P. Flint, Urbana, Illinois; C. H. Richardson, Ames, Iowa; W. H. Martin, New Brunswick, New Jersey; I. E. Melhus, Ames, Iowa; J. F. Adams, Vice-chairman, Newark, Delaware; H. J. Patterson, College Park, Maryland; W. H. MacIntire, Knoxville, Tennessee, and R. Kellog, Washington, D. C., representing The American Association of Economic Entomologists, The American Phytopathological Society, The Association of Official Agricultural Chemists, and The National Research Council, respectively.

A total of 15 research projects were conducted on either a part or full-time basis of which 3 were brought to a close during the year. The headquarters for research projects or field work conducted in relation to the same were established in the following States: New Jersey, Pennsylvania, Illinois, Iowa, Florida, Delaware, Ohio, California, Connecticut, Massachusetts, Maryland, Virginia, Michigan, Colorado, Missouri, Oregon, Washington, Indiana, New Hampshire, Louisiana, New York, North Carolina, and South Carolina.

Research projects conducted during the year involved the following studies: Developing new copper fungicides, copper sulphate as a soil nutrient and plant amendment, relation of copper pots and copper lining for greenhouse benches in propagation of plants, propagation of pyrethrum, incorporation of nicotine or nicotine compounds in oil sprays, synthetic organic compounds as insecticides, various chemical compounds as fungicides, new fumigants (Proxate), incorporation of Halowax oil in petroleum oils, sulphuric acid

in weed control, utilizing carbon disulphid as a constituent of sprays, incorporation of pine oil in cattle sprays, improvement of codling moth sprays with newer forms of arsenicals, improving various forms of toxicants for insecticidal sprays, fungicidal studies with cuprous oxide and investigation of new materials for fungicidal and insecticidal sprays.

Full or part-time projects during 1935 were sponsored by the following companies: Nichols Copper Company; Stanco Incorporated, Moncanto Chemical Company, Dow Chemical Company, Liquid Carbonic Corporation, Halowax Corporation, Stauffer Chemical Company, Hercules Powder Company, General Chemical Company, Rohm and Hass Company, General Dyestuff Corporation, Metals Refining Company, A. G. Kay and J. C. Makepeace.

Publications during the year in the institute series included the following:

Bulletin No. 49, The Toxicity of Carbon Dioxide-Methyl Formate Mixtures to the Confused Flour Beetle (Tribelium confusum Duv.), by R. M. Jones.

Bulletin No. 50, A Method for Comparing the Ovicidal Properties of Contact Insecticides, by E. P. Breakey and A. C. Miller.

Bulletin No. 51, Halowax as an Oviciде, by E. P. Breakey.

I. E. MELHUS,
W. H. MARTIN,
J. F. ADAMS.

THE AMSTERDAM MEETINGS

Report of the Official Representative Committee of the Society, Sixth International Botanical Congress and International Union of Biological Sciences, September, 1935, Amsterdam.

(Note: About 40 members of the Society were in attendance at Amsterdam, approximately two-thirds coming from the United States. Canada was represented by four and other foreign countries by at least twelve members. H. P. B.)

International Union of Biological Sciences. Adherence of the United States to this International Union was made possible by the action of the National Research Council in the summer of 1935. It fell to members of your committee to cast the votes of the United States at the Amsterdam meeting on September 1, due to the fact that no other American societies had arranged for accredited representatives.

An American botanist, Doctor E. D. Merrill of Harvard University, was elected President of the Union.

A Subsection of Phytopathology was authorized in the Botanical Section. Doctor Donald Reddick, Cornell University, was elected Vice-President of the Botanical Section.

Several other subsections were authorized including a Subsection of Applied Botany. The latter was authorized with the distinct understanding that it should not include phytopathology. Your representatives voted against the organization of this subsection and also against the organization of a Subsection on Forestry, which was defeated.

Sixth International Botanical Congress. Members of your committee attended all sessions of the Subsection on Nomenclature, including the special sessions held by the Mycologists, as well as all sessions of the Section on Phytopathology. The results of all official actions taken at the various meetings will be published elsewhere in detail.

The actions of chief interest to this Society were:

(1) *GENERAL RESOLUTION.*

It is proposed that the Botanical Section of the International Union of Biological Sciences should act as an administrative connecting link between the successive International Botanical Congresses, which maintain their full independence from an international

point of view to such an extent that any country that has not joined the Union, will have quite the same rights as those that have joined.

It is proposed that this Botanical Section be authorized to carry through any resolutions, carried by the International Botanical Congresses.

Proposed by A. C. SEWARD and seconded by J. C. SCHONTE, E. J. BUTLER, E. D. MERRILL, N. NĚMEC, M. J. SIRKS and N. E. SVEDELIUS.

(12) *SECTIONS, MYCOLOGY AND PATHOLOGY.*

The Sixth International Botanical Congress wishes to express its sincere appreciation of the admirable work accomplished by the Centraalbureau voor Schimmelcultures at Baarn since its foundation in 1906 and views with grave concern the present financial difficulties of what is essentially an international institution.

Proposed to the Section on Mycology by J. RAMSBOTTOM and seconded by E. J. BUTLER; to the Section on Pathology proposed by E. RHIEM and seconded by E. C. STAKMAN.

(13) *SECTION, PATHOLOGY.*

The Committee on Description and Nomenclature of Plant Viruses appointed by the Fifth International Botanical Congress 1930 wishes to report that it has made progress in developing a scheme for the nomenclature of plant viruses and suggests to this Congress that the Committee be empowered to continue its consideration and establish an acceptable system of virus nomenclature.

Proposed by H. M. QUANJER and seconded by JAMES JOHNSON, P. A. MURPHY, J. HENDERSON SMITH and G. SAMUEL.

(14) *SECTION, PATHOLOGY.*

It is recommended that the term "physiologic race" be substituted for "physiologic form," as the former seems more appropriate. It is recommended further that the word "race" be used in general to designate biotypes or groups of biotypes that differ from each other in physiologic characters.

Proposed by E. C. STAKMAN and seconded by Miss M. NEWTON, Miss G. MILBRINK and TH. ROEMER.

(15) *SECTION, PATHOLOGY.*

The Sixth International Botanical Congress expresses itself of the opinion:

that an effective and unceasing campaign against destructive plant diseases and insect pests can be successfully prosecuted only by international action and mutual cooperation;

that close and frequent international discussion of the problems of plant quarantines should take place to bring about improvement of the health conditions of plants and plant products offered for export;

that it unanimously recognizes that such action will greatly facilitate international trade in the commodities concerned, and

that, finally, this resolution be brought to the attention of the League of Nations, emphatically endorsing the League's proposal to give this matter urgent and careful consideration with a view to facilitating and expediting the purpose and aims of this resolution.

Proposed by H. T. GÜSSOW and seconded by N. VAN POETEREN.

The Seventh International Botanical Congress will be held in Sweden in 1940.

H. T. GÜSSOW, *Chairman*,
N. E. STEVENS,
J. C. WALKER.

REPORT OF COMMITTEE ON POTATO IMPROVEMENT

This committee, authorized at the St. Paul summer meeting of the Society on June 25, 1935, has studied the question of potato improvement and has reached the following conclusions:

1. That the production of disease-resistant varieties of potatoes offers one of the most promising means of controlling some of the most destructive potato diseases.

2. That the production of disease-resistant potato varieties, suitable in other respects, can most effectively be accomplished through a national cooperative potato-improvement program such as has been initiated by the office of Fruit and Vegetable Crops and Diseases of the United States Department of Agriculture and several State agricultural experiment stations.

3. That the members of The American Phytopathological Society as a group have a distinct responsibility to insure that the opportunities for potato-disease control offered by this program are utilized to the best advantage; that they should cooperate in every way possible and assume active leadership in the phytopathological aspects of the problem.

4. That the importance and promise of the national cooperative potato-improvement program is sufficient to justify its expansion with increased financial support.

To bring this matter to the attention of the proper administrative officers and technical workers, the committee prepared a short statement of the possibilities of potato-disease control through potato improvement and the need of a more adequate support of the national cooperative program. This was sent to the experiment station directors, to the Secretary of Agriculture, certain other interested administrative officers, and to the plant pathologist of each State station.

The committee has endeavored to encourage plant pathologists to take a more active part in the national program. At the St. Louis meeting of the Potato Association of America, the chairman presented a paper entitled "What the Plant Pathologist Can and Should Contribute to the Potato Improvement Program." The paper will be published in the American Potato Journal.

J. G. LEACH, *Chairman.*

REPORT OF SEED TREATMENT COORDINATING COMMITTEE

At the St. Paul summer meeting of the Society on June 25, 1935, a conference on seed treatment investigations resulted in the authorization of a committee on coordination in cereal seed treatment studies. It is the aim of this committee to encourage more uniform methods in experimentation and the recording of data, to stimulate coordination by arranging for a summer conference of the workers, to promote exchange of ideas, to find means of supplying the workers with the results of coordinated research, and to develop, on the basis of these, acceptable current control recommendations, which could be submitted for publication in PHYTOPATHOLOGY.

C. S. REDDY, *Chairman.*

REPORT ON THE TOBACCO DISEASE COUNCIL

Representatives of States interested in the production of tobacco and of the United States Department of Agriculture, including 16 members of the Society, met in conference at Greensboro, North Carolina, November 6 and 7, 1935, for the purpose of coordinating research work on diseases of tobacco. An organization designated as the Tobacco Disease Council was formed. An Executive Committee consisting of S. A. Wingard, Chairman, E. E. Clayton, R. F. Poole, W. D. Valleau, and G. M. Armstrong was named. Annual meetings of the Council will be held.

At the Greensboro conference, an extension discussion took place on various tobacco disease problems, ways and means of coordinating the efforts of the various workers, and the possibility of a cooperative regional attack on these problems. A study of the ecological relations affecting soil-borne plant parasites was listed as an important problem for a coordinated regional attack. Mimeographed copies of the proceedings of this conference were distributed. Research project outlines will be exchanged.

The Executive Committee will sponsor the organization of regional committees for the consideration of each major disease problem. These committees will summarize the data obtained from experimental work and make a report to the Council at the annual meeting.

A meeting of the Executive Committee was held January 2, 1936, in St. Louis.

R. G. HENDERSON, *Secretary.*

ACTION OF THE SOCIETY

Appointments. All appointments made by the President or Council since the previous meeting were ratified by action of the Society. These appear in the list of officers, representatives, and committees presented earlier in this report.

Reports of Officers and Committees. The various reports presented at the meeting, including that of the Resolutions Committee, were accepted by action of the Society. They appear earlier in this report.

Assistance to the Editor. On recommendation of the Council, it was voted to authorize the Editor-in-chief of PHYTOPATHOLOGY to make expenditures during 1936 up to $350 for clerical and editorial assistance as in the previous year.

Mel. T. Cook. It was voted at the Thursday morning session that the American Phytopathological Society congratulate Dr. Mel. T. Cook for his bibliographic publications on the literature on virus diseases of plants.

Federal Agency Thanked. The Society voted an expression of appreciation to Mr. Lee A. Strong, Chief of the Federal Bureau of Entomology and Plant Quarantine, and to his staff, for the courteous manner in which the resolutions of the Society passed at the Pittsburgh meeting concerning plant protection measures had been received and for the promptness and completeness with which requests by the Committee on Foreign Plant Diseases for information had been met.

Committee on Publication Problems. On recommendation of the Council it was voted to authorize the Council to appoint a committee to study and effectuate, with the approval of the Council, ways and means of meeting our increasingly complex problems of publication.

Limit on Free Illustrations. On recommendation of Council it was voted to authorize the Editorial Board to limit to two pages of half-tones or their equivalent the number of illustrations per article except where illustrations in excess thereof are paid for by the contributor.

Charge of $1.00 per Page Authorized. The Society endorsed the decision of the Council to exercise the authority granted at the Atlantic City Meeting in 1932 and direct a levy of $1.00 per printed page to be made on all contributions to PHYTOPATHOLOGY accepted after January 1, 1936.

Out-of-order Publication. On recommendation of Council it was voted that the Editorial Board continue during 1936, pending the development of plans looking to bringing publication up to date, the present policy of publishing out of chronolgical order papers paid for in full by the contributor or supporting agency.

Interest from the Lyman Memorial Fund. On recommendation of Council it was voted that the Treasurer be authorized to allocate to PHYTOPATHOLOGY future interest from the Lyman Memorial Fund.

Life Memberships Discontinued. On recommendation of Council it was voted that Article III, Section 2 of the Constitution, providing for life members and patrons be held in abeyance pending the submission of the membership of an amendment abolishing this section.

Publication of Abstracts Discontinued but Distribution Provided for. On recommendation of Council it was voted to discontinue publication in PHYTOPATHOLOGY abstracts of papers presented at meetings of the Society and its Divisions. It was voted by the Society that abstracts of papers presented at the annual meeting of the Society be mimeographed or printed (whichever would be cheaper) at the expense of the contributors and mailed to each member of the Society in advance of the meeting.

Time Limit on Papers. On recommendation of Council it was voted that no papers presented at the annual meetings, except invitation papers, should exceed 15 minutes in length.

Place of Next Annual Meeting. It was moved by N. E. Stevens and carried that the Council be empowered to arrange for the place of the next annual meeting.

Seal of the Society Authorized. It was voted on recommendation of the Countil that the Council be empowered to select an official seal for the Society.

Phytopathological Classics. It was voted to authorize the management of Phytopathological Classics to circularize the membership for advance subscriptions which would insure sufficient income, when added to funds already on hand, to permit the publication of the translations in this series, now nearly ready.

Resolution on Regional Coordination in Plant Disease Research and Control Programs. This resolution and that following were adopted by the Society on recommendation of the Extension-Research Conference.

It is the sense of this meeting that the American Phytopathological Society should formulate plant disease control programs after careful consideration by extension and research men. To this end it is desirable to have committees study individual problems and make recommendations at joint meetings of extension and research workers at the annual meetings. It also is desirable to stimulate coordinated regional effort through encouragement of regional meetings and cooperative endeavor in formulation of regional research and extension programs, and, when desirable and practicable, in the formulation of national problems.

Resolution on Coordination of Research and Extension Effort. It has become evident in recent years and as a result of discussions at joint extension and research conferences at the annual meetings that research and extension work would be far more effective if it were possible for extension and research men to cooperate more closely.

It is resolved, therefore, that this meeting recommend that The American Phytopathological Society call to the attention of National and State research and extension directors that urgent need for closer coordination of effort by research and extension workers.

Resolution on International Cooperation in Plant Protection. It was moved by H. W. Anderson and carried that the following resolution passed by the Sixth International Botanical Congress be endorsed by the Society and transmitted to the American Association for the Advancement of Science and the National Research Council and other interested agencies.

Resolved: "That an effective and unceasing campaign against destructive plant diseases and insect pests can be successfully prosecuted only by international action and mutual cooperation;

that close and frequent international discussion of the problems of plant quarantines should take place to bring about improvement of the health conditions of plants and plant products offered for export;

that it unanimously recognizes that such action will greatly facilitate international trade in the commodities concerned, and

that, finally, this resolution be brought to the attention of the League of Nations, emphatically endorsing the League's proposal to give this matter urgent and careful consideration with a view to facilitating and expediting the purpose and aims of this resolution.''

Dutch Elm Disease Resolution. On recommendation of Council the Society passed the following resolution:

Resolved: That The American Phytopathological Society recommend to the Council of the American Association for the Advancement of Science that it strongly endorse the efforts of Federal and State Agencies to control the Dutch elm disease, and, furthermore, that the Council of the American Association for the Advancement of Science be respectfully requested to take such measures as may be necessary to bring to the attention of the proper authorities the desirability of continued and adequate support of the Dutch elm disease control project.

The following six resolutions were prepared by the Committee on Foreign Plant Diseases, in accordance with instructions by the Society, and adopted by vote of the Society at the Wednesday evening conference.

Resolution on Need for More Adequate Plant Detention Services. Resolved: That in view of the great danger of releasing imports before complete freedom from dangerous plant diseases can be assured, more adequate detention services be established, and that this resolution be communicated by the Committee on Foreign Plant Diseases to the Secretary of Agriculture, the Chief of the Bureau of Entomology and Plant Quarantine, and other officials concerned with the administration of these services.

Resolution on Study of Foreign Plant Diseases Abroad. Resolved: That the policy of sending specialists into foreign countries to study potentially dangerous plant diseases be continued and expanded, and that this matter be brought before the proper authorities by your committee.

Resolution on Foreign Biotypes of Plant Pathogens. Resolved: That the same caution be taken with respect to the introduction of biological races of dangerous plant parasites as is considered necessary in the case of specific entities.

Resolution on Import of Living Cultures of Plant Pathogens Under Permit. Resolved: That in view of the potential dangers of the unrestricted entry of living cultures of plant pathogens, the Society recommends that such cultures be permitted import only on permit. At the same time the Society is cognizant of the need of living cultures for scientific purposes and recommends as free entry of such cultures as is consistent with adequate safeguards in the national interests.

Resolution on Extension of Elm Disease Survey. Resolved: That the present policy for extending search for the Dutch Elm Disease is inadequate and that the Society urges the extension of survey work into all territory where elms are grown and where there may be a possibility of this disease having become established.

Resolution on Feasibility of Potato Wart Eradication. Resolved: That a further statement of evidence on the feasibility of carrying out eradication methods in case of the Potato Wart Disease be prepared and presented to the Chief of the Bureau of Entomology and Plant Quarantine.

SAMUEL HENRY ESSARY

SEPTEMBER 11, 1870—APRIL 28, 1935

Samuel Henry Essary was graduated from the University of Tennessee in 1897 and received the degree of Master of Science from the same institution in 1907. From 1899 to 1902, he was instructor in science in La Grange College, La Grange, Missouri, and from 1902 to 1904 he taught science in Brenau College, Gainesville, Georgia. In 1904 he was appointed instructor in botany, University of Tennessee, and assistant botanist in the Tennessee Agricultural Experiment Station. Subsequently, he was promoted successively to associate botanist and botanist of the Experiment Station, which latter position he held to the time of his death.

He was an active member of a number of scientific and social organizations and was a charter member of The American Phytopathological Society. He did notable work in developing anthracnose-resistant clover and wilt-resistant tomatoes. He was an enthusiastic naturalist and loved the "Great Out-of-doors" and all it contains: the natural scenic beauty as well as the native flora and fauna, which he knew so well in his area. While he did no formal teaching, particularly in his later years, yet he was a great inspiration to the younger botanists, with whom he loved to associate. In the words of one of these " . . . his greatest pleasure was to see the science for which he had devoted his own life advanced by the accomplishments of those younger men in whom he was especially interested."

HERMAN JOHN NINMAN

MAY 4, 1876—OCTOBER 24, 1934

Herman John Ninman was graduated from the University of Wisconsin in 1913 with the degree of Bachelor of Science in Agriculture, and in 1917 he received the degree of Master of Science from the same institution.

From 1914 to 1915, Mr. Ninman was principal of the Tripoli High School, Tripoli, Wisconsin. From February 1 to April 30, 1917, he was employed by the Federal Bureau of Plant Industry at Madison, Wis., as assistant in tobacco disease investigations. During the following summer he was employed as a member of a white pine blister rust scouting crew in northwestern Wisconsin. During the same fall he served for a time as nursery inspector in the office of the State Entomologist of Wisconsin. From December 18, 1918, to the time of his death, he served almost continuously as Agent on the rolls of the U. S. Department of Agriculture in various capacities in connection with white pine blister rust activities in Wisconsin.

Mr. Ninman was a most earnest, highly dependable worker, always working with patience and unusual tenacity. While he was very unassuming in his attitude, he was always ready to encourage a worthy cause and to help its advancement in any way he could.

FRANK LINCOLN STEVENS

APRIL 1, 1871—AUGUST 18, 1934

Frank Lincoln Stevens was graduated from Hobart College, Geneva, N. Y., in 1891 and received the degrees of Bachelor of Science and Master of Science from Rutgers University in 1893 and 1897, respectively. In 1900 he received the degree of Doctor of Philosophy from the University of Chicago. In 1925 he was given the honorary degree of Doctor of Science by San Marcos University, Peru, and in 1931 he received the honorary degree of Doctor of Laws from the University of Glasgow.

During 1898 and 1899, Dr. Stevens served as analyst for the Chicago Drainage Commission while he was pursuing graduate study at the University of Chicago. In 1901 he served as instructor in biology at the North Carolina State College, and in 1902 he became professor of botany and vegetable pathology in the same institution, which position he held until 1912. From 1903 to 1912, he also was biologist for the North Carolina Agricultural Experiment Station. From 1912 to 1914 he served as dean of the College of Agriculture, University of Puerto Rico. From 1914 to the time of his death, except for temporary absences, he served as professor of plant pathology in the department of botany at the University of Illinois. During 1921–1922, he held the Bishop Museum Fellowship from Yale and spent the year collecting fungi in the Hawaiian Islands; in 1924–1925 he made an extensive collecting trip in South America; and in 1930–1931 he held the Baker Memorial Professorship of Botany at the University of the Philippines. He was active in a number of scientific societies and was a charter member of The American Phytopathological Society and its second president.

Dr. Stevens was the author of numerous books and scientific papers. He was a man of broad interests in the field of biology. He had unusual foresight, was a very keen observer, tireless collector, inspiring teacher, able investigator, and ready writer. He was always highly considerate of others, ever congenial, yet dignified. It has been truly said of him that "his keen sense of right and his firm but calm and kindly spirit endeared him to all who worked with him."

JAMES M. VAN HOOK

DECEMBER 19, 1870—JUNE 20, 1935

James M. Van Hook was graduated from Indiana University in 1899 with Bachelor of Arts degree and received the degree of Master of Arts from the same institution in 1900. During 1900–1901 he was assistant in botany, Cornell University, and from 1902–1904, he was assistant in plant pathology in the Extension Department of Cornell University. From 1904 to 1907 he was assistant botanist at the Ohio Agricultural Experiment Station. In 1907 he was appointed assistant professor of botany, Indiana University, and subsequently was promoted successively to associate professor and to full professorship in 1925, which position he held to the time of his death.

Professor Van Hook was active in a number of scientific societies and was a charter member of The American Phytopathological Society. He was an able investigator and a very capable, enthusiastic teacher. He contributed much to our knowledge of the cause and control of certain diseases of ginseng and of peas and added greatly to our knowledge of the fungus flora of Indiana. It is said of him by one of his associates that: "His friendships were deep and lasting. Those who knew him recognized and admired his integrity, sincerity, kindness, and loyalty; and were impressed with his knowledge, skill, and ability in the field of botanical science, which he loved."

PHYTOPATHOLOGICAL SUMMER MEETING

IOWA STATE COLLEGE, AMES, IOWA
JUNE 25–26, INCLUSIVE

First Day

9:00 A.M.: Registration, Botany Hall, Room 202.
Tour through Laboratory and Greenhouses.

1:00 P.M.: Tour of Phytopathological Plots, Agronomy Farm, Horticultural Orchards, and Federal Erosion Nursery.

6:30 P.M.: Dinner, Memorial Union.

8:00 P.M.: Extension Workers' Round-table Discussion.
Coordination of Programs.

9:00 P.M.: Round-table Discussion—Research.
Relation of Phytopathology to Erosion Control.

Second Day

8:00–10:30 A.M.: Research—Round-table Discussion.
Is There a Place for Regional Research Programs in Plant Pathology?

12:30 P.M.: Dinner, Leader Cafe, Kanawha.

1:30 P.M.: Excursion to Northern Iowa Experimental Farm, Kanawha, Iowa—Cereals, Beets, Potatoes, etc.
Excursion to Southeastern Experimental Farm, Conesville, Iowa—Melons, Sweet Potatoes, Other Truck Crops.
Excursion to Western Iowa Fruit Section, Glenwood, Iowa—Apple Spraying, Apple Root Rot, Nursery Diseases.